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MODERN SEAMANSHIP

BY

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EIGHTH EDITION

REVISED AND ENLARGED

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PREFACE TO EIGHTH EDITION

A large part of the present edition of Modern Seamanship has been entirely rewritten and the remainder carefully revised. At all points it has been as completely as possible brought up to date.

A comparison with the Seventh Edition will indicate that the most extensive changes are, as would naturally be expected, in the earlier chapters; that is to say, in the chapters which deal with *materials* rather than with *principles*. Important changes have, however, been made in the later chapters and considerable new matter has been added. The chapters on *Submarines* and *Submarine Chasers* and the final chapter, on "*Assistance by Public Vessels to Vessels in Distress*" are entirely new, and that on *Destroyers* is practically so.

The *Rules of the Road* have been re-arranged to provide for easy comparison of the Inland with the International Rules.

Much care has been taken in the arrangement of plates to bring each one as close as possible to the text with which it is associated.

In the preparation of this, as in that of other editions, assistance has been sought from many sources, and the author acknowledges with high appreciation the help received from a large number of his brother officers of the Navy, the Coast Guard, and the Merchant Marine.

The Officers of the Seamanship Department of the Naval Academy have contributed suggestions of much value, based upon experience in the use of the work as a text book.

Captain W. L. Littlefield of the Bureau of Construction and Repair has been untiring in his interest and helpfulness. A large part of the material in the chapters on *Ground Tackle* and *Boats* has been supplied by him, with the approval of the Chief of Bureau.

The Chapter on *Destroyers*, in its new form, is chiefly the work of the Lieutenant Commander W. W. Smith; that on *Submarines* is by Lieutenant Wilder D. Baker, and that on *Submarine Chasers*, by Captain A. J. Hepburn. It is believed that these three

chapters will be recognized as among the most interesting and valuable in the book.

It is a pleasure to acknowledge the generous co-operation of Commodore W. E. Reynolds and other officers of the Coast Guard, and the very valuable assistance received from them, in connection, especially, with "Boats" (Chapter IX) and "Assistance to Vessels in Distress" (Chapter XXIX).

Valuable information and suggestions were received from Rear Admiral W. S. Sims, Rear Admiral H. B. Wilson, Rear Admiral J. A. Hoogewerff, Rear Admiral H. P. Jones, Rear Admiral L. H. Chandler, Captain C. T. Vogelgesang, Captain W. A. Moffett, Captain T. T. Craven, Captain C. T. Owens, Captain C. S. Kempff, Commander R. S. Holmes, Commander J. P. Lannon, Commander S. C. Hooper, Lieutenant T. A. M. Craven and Lieutenant G. D. Barringer, all of the Navy, and from Captain B. H. Camden, Commander H. G. Hamlett, Lieutenant-Commander F. C. Billard, and Lieutenant-Commander H. C. Roach, of the Coast Guard. Also from Captain E. K. Roden of the International Correspondence Schools, and Captain Felix Reisenberg, recently Editor of "The National Marine."

Information was courteously furnished by the American Steel and Wire Co., The Columbian Rope Co., The Waterbury Co., The Plymouth Cordage Co., The John T. Roebling's Sons Co., The General Electric Co., The Sperry Gyroscope Co., The American Balsa Co., The Steward Davit and Equipment Co., The American Engineering Co., The Hyde Windlass Co., The Kelvin and Wilfred O. White Co., T. S. and J. D. Negus, and John Bliss & Co.

AUSTIN M. KNIGHT.

WASHINGTON,
August 30, 1921.

PREFACE TO FIRST EDITION.

An attempt is made, in the following pages, to cover a wider field than that covered by most of the existing works on Seamanship.

The admirable treatises of Luce, Nares, and Alston, originating in the days when seamanship was almost wholly concerned with the fitting and handling of vessels under sail, have preserved through later editions the general characteristics which they naturally assumed in the beginning. These treatises will never be out of date until the time, still far in the future, when sails shall have been entirely driven out by steam. It will hardly be denied, however, that the Steamer has long since established its claim to consideration in Seamanship, and that there is room for a work in which this claim shall be more fully recognized than in the treatises above referred to. The excellent work of Captains Todd and Whall, "Practical Seamanship for the Merchant Service," deals more fully than either of its predecessors with the handling of steamers; but its point of view is, as its name implies, primarily and almost exclusively that of the Merchant Service.

Shortly after the present work was begun, a circular letter was addressed to officers of the merchant service and extensively circulated through the Branch Hydrographic Offices at New York, Philadelphia, Baltimore and Norfolk, requesting the views of the officers addressed.

The answers received to these questions were unexpectedly numerous and complete. More than forty prominent officers of the Merchant Service replied, many of them writing out their views and describing their experiences with a fullness of detail far beyond anything that could have been anticipated.

The thanks of the author are due particularly to the following for letters or for personal interviews covering the above points: Capt. W. H. Thompson, S. S. Belgenland; Capt. T. Evans, S. S. Runo; Capt. J. Dann, S. S. Southwark; 1st Officer T. Anfindsen, S. S. Southwark; Capt. J. C. Jameson, S. S. St. Paul; Capt. H. E. Nickels, S. S. Friesland; Capt. G. J. Loveridge, S. S. Buffalo; Capt. F. M. Howes, S. S. Kershaw; Capt. T. J. Thorkildsen, S. S. Trojan; Capt. Otto Neilsen, S. S. Pennland;

Capt. H. Doxrud, S. S. Noordland; Capt. C. O. Rockwell, Clyde S. S. Co.; Capt. S. W. Watkins, S. S. Montana; Capt. Anders Beer, S. S. Nordkyn; Capt. J. M. Johnston, S. S. Sardinian; Capt. A. R. Mills, S. S. Westernland; Capt. J. S. Garvin, S. S. Cherokee; Capt. Robt. B. Quick, S. S. El Cid; Capt. Wm. J. Roberts, S. S. New York; Capt. T. Richardson, S. S. Noranmore; Capt. E. O. Marshall, S. S. Maryland; 1st Officer H. S. Lane, S. S. Maryland; Capt. W. F. Bingham, S. S. Marengo; Capt. R. Gowing, S. S. Greatham; Capt. H. J. Byrne, U. S. A. T. McPherson; Capt. Paul Grosch, S. S. Stuttgart; Capt. Geo. Schrotter, S. S. Belgravia; Capt. F. C. Saunders, S. S. English King; Capt. Chas. Cabot, S. S. Venango; Capt. Chas. Pinkham, S. S. Queen Wilhelmina; Capt. A. Traue, S. S. München; Capt. W. Thomas, S. S. Quernmore; Capt. H. O. Nickerson, Fall River Line; Capt. Geo. Lane, Baltimore Steam Packet Co.

Important assistance was received from Naval Constructor W. J. Baxter, U. S. Navy, who prepared Chapters I and XVIII; and from Lieutenant E. E. Hayden, U. S. Navy, who contributed several Charts and much valuable information upon Meteorology, for Chapter XIX.

Chapter V was suggested by a paper, "Mechanical Appliances on board Ship," by Captain Thomas Mackenzie, issued by the London Shipmasters' Society as No. 29 of their valuable series of publications.

It would be impossible to mention all the naval officers who have assisted the author with criticism and suggestions; but acknowledgment is especially due to Lieut.-Commander A. W. Grant, Lieut. John Hood, Lieut. W. R. M. Field, Lieut. John Gow, Lieut.-Commander W. F. Worthington, Commander J. E. Pillsbury, Lieut. V. S. Nelson, Lieut. Ridgely Hunt, and Chief Boatswain W. L. Hill, all of the United States Navy.

Above all, acknowledgment is due to Chief Boatswain C. F. Pierce, U. S. Navy, who not only assisted in the preparation of many parts of the text, but prepared sketches for fully one-half the illustrations of the volume.

AUSTIN M. KNIGHT.

UNITED STATES NAVAL ACADEMY,
APRIL 1, 1901.

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CHAPTER I.

THE SHIP.

The size, form, speed, power, armor, armament and rig of a ship depend upon the nature of the services she is expected to perform. Whatever her design may be, she must have ample stability, strength, habitability, and a complete outfit of all appliances, fixed and portable, necessary to ensure her efficiency under all service conditions.

The broadest classification of ships is that which distinguishes them as *Ships of War* and *Merchant Ships.* Ships of War in turn may be distinguished as *Fighting Ships* and *Auxiliaries.* Our principal concern is with fighting ships; but it must not be forgotten that in these days of large naval and military operations, often at great distances from home ports, the life of the fighting fleet depends very largely upon its auxiliaries—fuel ships, supply ships, repair ships, etc.—forming the complex organization known as the *Train.*

Fighting Ships are of many classes, used for widely varying purposes calling for widely varying designs—designs which, starting from certain definite limitations of size and cost, must be developed along such lines and with such a balance of the factors of offensive and defensive power involved as shall give maximum weight to the factors most important for the purpose in hand without unduly sacrificing the remaining factors.

Modern warships are usually classified as follows:

FOR SERVICE WITH THE FLEET.

Fighting Units.	*Auxiliary Units* (the Train).
Battleships	Fuel ships
Battle cruisers	Transports
Scout cruisers	Supply ships
Light cruisers	Repair ships
Destroyers	Mine laying and
Submarines	Mine sweeping ships

For Independent Service.

Cruisers	Training ships, etc.
Gunboats	

For Coast Defense.

Second-line battleships	Mine layers
Second-line destroyers	Patrol ships and scouts
Monitors	Aircraft

Battleships. (Plate 1.) A *battleship,* being designed to take a place in the line of battle, meeting the most powerful ships of the enemy and exchanging blow for blow, must have defensive qualities to resist the heaviest blows she is likely to receive. Hence her armor must be heavy. But more important than the power to resist, is the power to strike. It is an axiom that "the best defense is a vigorous offense." Thus, for a battleship the *first* requisite is a heavy armament; the second, heavy armor. Speed is not here of maximum importance, although by no means negligible. In the design of a battleship, then, we sacrifice something in weight of armor for weight of armament, and something in weight of boilers and engines—that is to say, in speed—for armament and armor combined; while for these three primary factors taken together—armament, armor, and speed—we sacrifice much in the important factor of fuel-endurance and in other less significant factors which need not be enumerated here.

Up to the time of the Russo-Japanese War, 1904–5, and for some years thereafter, the common type of battleship carried a mixed armament of heavy, light, and intermediate guns. As a result of experience gained in that war, Great Britain in 1906 laid down, with much secrecy, a new type, the distinguishing feature of which was that it carried only guns of the heaviest caliber and all of these protected by the heaviest armor. The first of these "all-big-gun" ships was named the "Dreadnought" and this name was immediately seized upon as the name of the type, so that "Dreadnought" came to signify, at first an all-big-gun ship, and, later, a powerful battleship of any type without reference to the character of the armament. More recently, we have had "Super-Dreadnoughts," the term being used in a popular way to designate a ship which is assumed to be more powerful

Plate No. 1.

A BATTLESHIP.

than any of its predecessors. The pendulum whose swing from too great diversity of armament led for a time to the removal of all except the heaviest guns has swung back to some extent, and even the super-dreadnought of today carries a battery of light guns for defense against torpedo craft and submarines, while ships of every class carry "anti-aircraft guns" capable of firing almost directly upward.

Battle Cruisers. (Plate 2.) In a *battle cruiser,* the requirement of high speed comes first, accompanied by that of large fuel supply, or, what is the same thing, large radius of operations. Next in importance comes armament; while armor protection drops to third place with an importance much below that of the other factors. While the battleship holds its place in the battle line, the battle cruiser may range far afield searching for the enemy—thus playing the part of an advanced scout—or take advantage of its high speed and heavy armament to turn the enemy's flank or throw itself upon some part of the line where its weight, coming perhaps as a surprise, may produce decisive results. A force of battle cruisers may be described as the heavy cavalry of the sea. Such a force gives *flexibility* to the fleet of which it forms a part and lends itself to combinations which afford scope for a high order of tactical skill on the part of the commander-in-chief.

Of late there has been a tendency to combine the characteristics of the battleship and the battle curiser in a single design. This tendency, if carried to full realization, would result in a ship having the armor and armament of the "California" with a speed 30 per cent. higher. Such a combination is possible only by an enormous increase in displacement, and would result in a ship of approximately 60,000 tons, a little short of 1,000 feet in length (to admit a passage through the locks of the Panama Canal) and with a draft of nearly or quite 40 feet. It may be that such a ship will be the next development in fighting-ship design, but it can hardly be said to be in sight today. The British fast battleship "Hood" is the nearest approach to it thus far attempted, and the "Hood" is recognized as an experiment of doubtful success.

Scout Cruisers.[1] (Plate 3.) A scout cruiser needs, first of

[1] In the United States Navy, *Scout Cruisers* are now called "Light Cruisers of the First Line."

Plate No. 2.

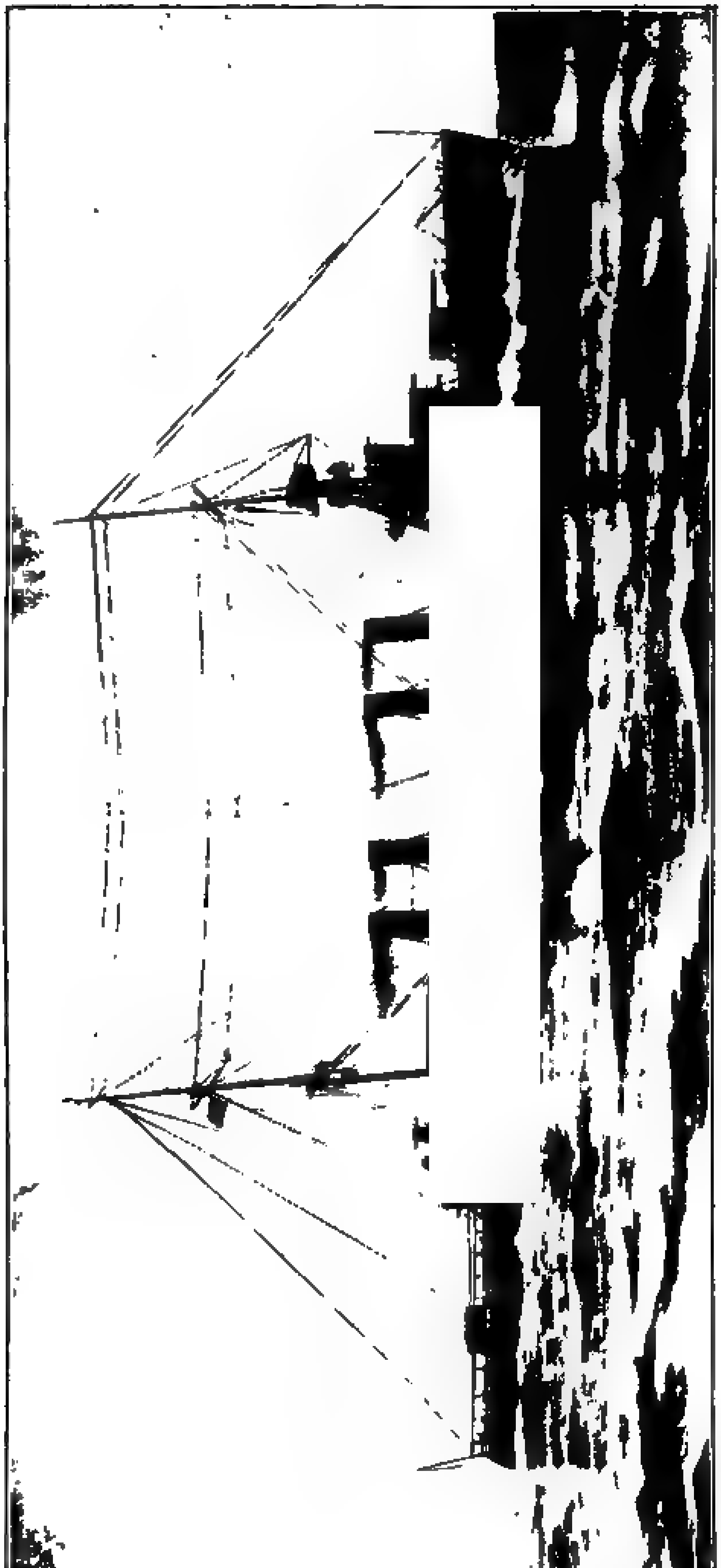
A BATTLE CRUISER.

all, high speed, which, however, must be accompanied by large fuel capacity and a high degree of seaworthiness, both of which characteristics are necessary to make high speed available for distant scouting under all conditions of weather. The armament is light, though one long-range gun may be very useful; and little or no weight can be spared for armor except for an armored deck. The function of a scout is sufficiently defined by the name. The scouting area that can be covered is rapidly being extended by the development of aircraft, which can now be carried by ships and launched from their decks, while the power of keeping in touch with the commander-in-chief and sending in reports of observations is being coincidently extended by improvements in radio-telephony.

All this makes of the scout of today a vastly different craft from that of only a few years ago and promises to revolutionize all those phases of naval warfare which precede and lead up to the actual contact of opposing fleets.

Light Cruisers (Plate 3) usually operate with the fleet, especially in the preliminary stages of contact with the enemy. It is their function to keep touch with the enemy, reporting his movements, his forces, etc., to the commander-in-chief and driving back the opposing cruisers and destroyers if these attempt an attack. Their armament, especially designed for stopping other cruisers and destroyers, consists of a large number of light rapid-firing guns; and as they carry torpedoes and have high speed and great flexibility of maneuvering, they have a wide range of usefulness within limits which do not take them far from base or from support.

Destroyers. (Plate 4.) The destroyer has passed through many phases of evolution since it was first conceived as a craft designed to "destroy" the torpedo boats by which torpedo warfare was chiefly conducted forty years ago. The earlier torpedo boat rapidly gave place to the larger but very similar craft that had been called into existence to oppose it, and the name "torpedo-boat destroyer" soon gave place to the abbreviated form now in every-day use. Primarily, then, the destroyer is a torpedo boat—large, heavily armed, and the fastest type of warship known. The light guns with which it was originally equipped for use against the thin plating of other torpedo craft have grown to a size and power that place the destroyer offensively, and with-



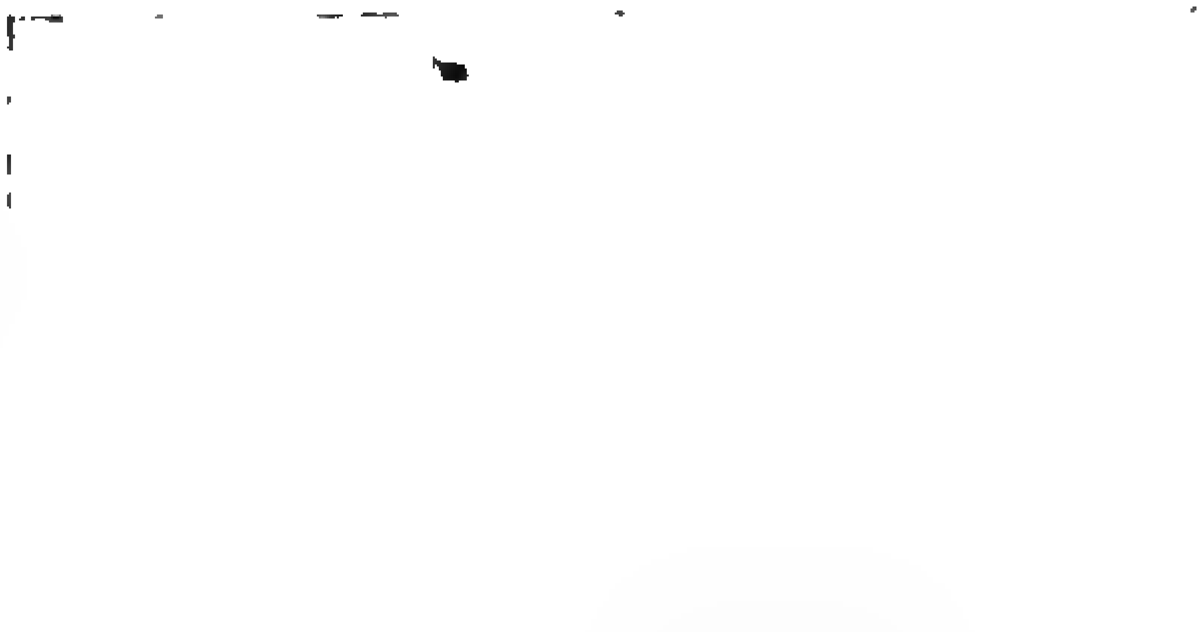
A SCOUT CRUISER. (Light Cruiser, First Line).

out reference to its torpedoes, in a class with large gunboats and light cruisers, while its great speed and the large number of torpedoes that it carries place it distinctly in a class by itself.

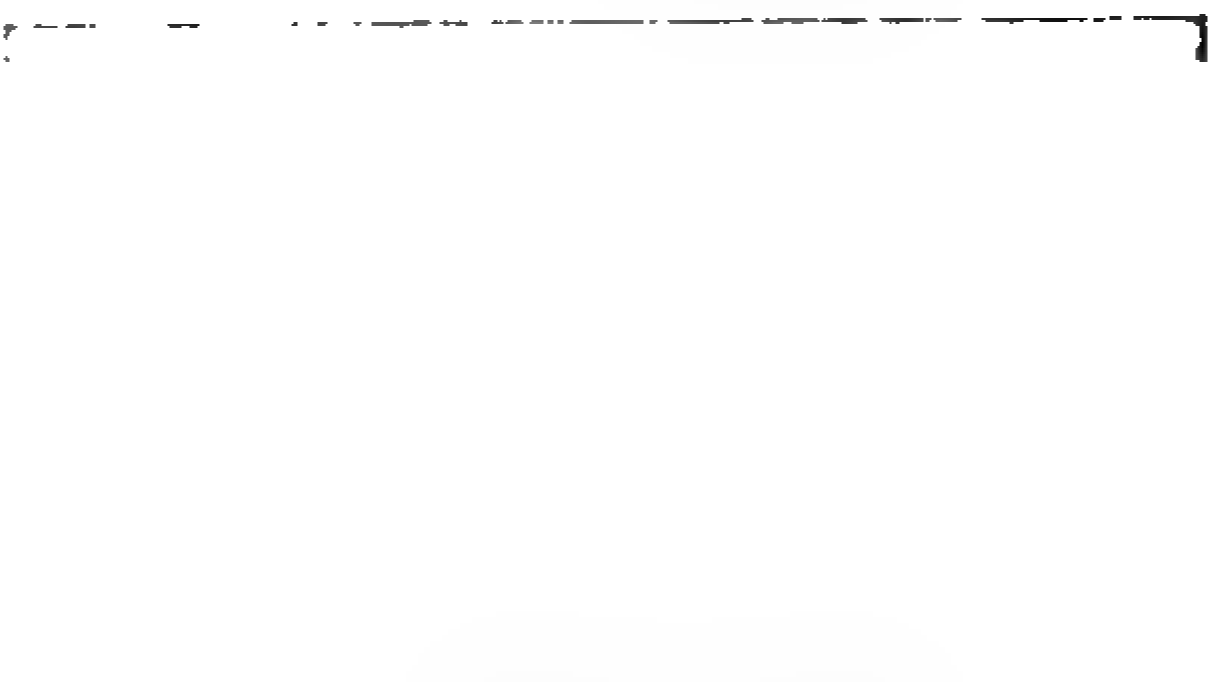
The World War of 1914 to 1918 resulted in great developments in the characteristics of the destroyer and a wide extension of its field of usefulness. It proved the most efficient opponent of the submarine and the most successful protector of commerce from submarine and other forms of attack. Among the many novel features that were developed as weapons during the war, the most interesting were the *depth bomb* and the *direction-listening device,* both of which found their most important and successful application on destroyers.

Submarines. (Plate 4.) The *submarine,* in principle, goes back to the inventions and experiments of Bushnell (1775) and Fulton (1801), both of whom had a fairly complete conception of the possibilities of warfare under water. In its modern and successful application, it dates from the pioneer work of Holland (1875) and Lake (1895). Even today, submarine navigation, whether for naval or for commercial purposes, is unquestionably in the early stages of development, in spite of the tremendous significance of its operations in the recent war.

By devices which vary with different types, the submarine can pass from the surface of the water to a depth which is limited only by the power of the hull to withstand the pressure of the water, and can maneuver there at the will of those in control. While there are important differences between the various types of submarines which have had more or less success within the last thirty years, the essential principle of the most successful types may be stated as follows: Under normal conditions, the boat floats like any other craft. Certain compartments are fitted for the admission of seawater through valves operated by the person in charge of maneuvering. With these compartments filled, the boat still has sufficient buoyancy to remain on the surface although very deeply immersed. In other words, the boat has a certain small amount of *reserve buoyancy* when all her sinking tanks are filled. To submerge, it is necessary that she should be *steered* under water, by going ahead, with her horizontal fin-like rudders technically known as "hydroplanes" swung downward, in which position their action is to steer the craft down exactly as an ordinary vertical rudder, when swung to the right,



A LIGHT CRUISER. (Second Line).



A DESTROYER

A SUBMARINE.

steers the boat to the right. Conversely, of course, the hydroplanes, when swung upward, steer the boat toward the surface. The moment that the rudders are brought to the midship (horizontal) position, the reserve bouyancy asserts itself, and the boat rises. The same result occurs, of course, if the headway is stopped. Thus there is always a tendency, *inherent in the craft itself,* to seek safety by rising to the surface, and a positive force must be applied, by the motion of the boat combined with the effect of a "down rudder," to maintain submersion. In this lies the characteristic feature of the modern type of submarine. In operating on the surface, the power used is that of gas engines; under water, that of electric storage batteries. When completely immersed, the submarine is not only invisible to others but is itself blind, since practically nothing can be seen from it through the water. At moderate depths this difficulty is met by the use of the periscope, a long tube which, at depths up to about 30 feet, projects above the surface, with lenses which give a good view around the horizon.

Contrary to the general impression, the normal life of a submarine is on the surface, where she navigates freely under her gas engines and where the crew have opportunities for rest and fresh air and a limited amount of exercise on deck. Both the speed and the distance which can be run when submerged are very limited, owing to the limitations of the electric batteries. After a few hours of running submerged the power of these becomes exhausted and the submarine must return to the surface, where the gas engines can be used to *recharge* the batteries, after which another period of submerged running becomes practicable. It follows from this that the submarine is by no means the always-invisible enemy that it is generally considered. Unless the periscope at least is above water, the submarine is blind. And if the periscope is exposed, small as it is, it is open to detection by a lookout sufficiently keen. To this danger of detection by sight is added an equally serious danger of detection by sound; for devices by which the noise of a propeller can be detected and its direction and approximate distance determined are now installed on all vessels designed to cope with submarines. It is found, moreover, that an aircraft flying at a height of a few hundred feet can see to a considerable distance below water, especially if the water is smooth, and can locate a submarine even when the

periscope is not exposed. A submarine once detected and approximately located is in very serious danger. If she exposes herself on the surface she is subject to attack by gun-fire. If she remains submerged, she is in almost equal danger of attack by depth-bombs, which, loaded with heavy charges of high explosive, are dropped overboard as near as possible to the spot where she is supposed to be, with fuses adjusted to produce explosion at a depth of 100 feet or thereabouts below the surface. Approximately fifty German submarines are reported to have been destroyed by depth-bombs during the last year of the World War.

From what precedes it may be concluded that while the submarine is probably destined to play an important part in future wars, it will be a part lacking much of the stealthiness and mystery which characterized its operations in the early months of the recent war. To a large extent, its fangs are drawn. It remains a serious danger, but a danger which does not differ greatly from the other dangers with which modern naval warfare abounds.

Naval Auxiliaries.—Space does not permit a description of these, nor is such description necessary. But no list of types would be complete which did not recognize their importance and the highly specialized characteristics which they have taken on in recent years. It is no longer felt that the upkeep of the fleet can be left to the chance of finding merchant ships which at need can be utilized to carry fuel, ammunition, provisions, etc., for fifty or a hundred men-of-war of various types acting in distant waters, whether in peace or war.

Cruising Ships.—The desirability—indeed the necessity—of keeping the fighting fleet together, to be constantly in training for operations as a unit, makes it necessary for Governments having interests in distant quarters of the world to maintain a certain number of ships for independent service in foreign waters. As a rule, the ships employed in this service are unarmored cruisers or gunboats of moderate size, preferably armed with many guns of medium and small caliber, and carrying crews large enough to permit the landing, in case of necessity, of an effective force of men.

Coast Defense Ships.—For the "Second Line of Defense" reliance is placed upon battleships and destroyers a little out of date for the "First Line" (the fleet), associated with such other

craft, usually rather heterogeneous in character, as may be available. *Mine-layers* are likely to develop into a definite and useful type as a result of the experience gained during the World War; and *air-craft,* operating far to seaward from a land base, or from a new type of ship—the "Sea-plane Carrier"—of good size, high speed and ample deck space, equipped with elaborate facilities for the stowage, handling, launching and landing of air-craft, will be a feature of all future defensive operations. Small, light, fast craft of the general type known during the recent war as "submarine chasers" will patrol the coast, and, in connection with destroyers, convoy merchant vessels through regions where submarine activities are to be feared.

Although the *Monitor* type of coast defense ship is nearly obsolete, it is worthy of mention here, if only because of its relation to the Dreadnought of today. The Dreadnought is, in fact, the logical outgrowth of the American Monitor of 1862. In the original Monitor we have a typical "all-big-gun" ship, with all (both) of its guns of the heaviest caliber known at that day, and all (both) of these guns carried in a revolving turret behind heavy armor. The hull, too, was protected as completley as possible, and the ship was maneuvered from an armored conning tower. From the Monitor to the Super-Dreadnought the road is long, but direct; or, if the road has sometimes deviated from a straight line, it has been only to come back to the line marked out by Ericsson.

Merchant Steamers (Plate 5) are of many types, varying in their characteristics even more widely than men-of-war. They may be broadly divided into *freight carriers* and *passenger carriers,* although most passenger carriers carry freight also. In time of war they may carry guns, usually for defensive purposes only. They are never armored. While a first-class passenger steamer will cross the ocean at a speed of from 20 to 25 knots, the average "Tramp" makes from 8 to 11 knots only; economy of fuel and personnel being of the first importance to such ships. The interior arrangements and the division of space are determined by the necessities of the service; the handling and storage of cargo being among the vital factors considered. In steamers carrying passengers, modern laws require that great attention be given to boats and other life-saving apparatus.

In merchant ships, as in men-of-war, water-tight subdivision

and integrity are vitally important. As merchant ships habitually, though not invariably, lie at a dock when in port, while men-of-war commonly ride at anchor, the sides of merchant ships are clearer of projecting obstructions than those of men-of-war, the guns of the latter alone often proving an embarrassment in going alongside a dock or another vessel.

Sailing Ships (Plate 5), which a few years ago seemed likely to disappear from the seas, are increasing in number, and appear to be entering upon a new, though limited, career of usefulness in the transportation of non-perishable cargoes. They are often equipped with engine power sufficient to drive them at a moderate speed when the wind fails.

Naval Aviation is yet in its infancy and no one can say what lines of technical development it is to follow. Whatever these lines may prove to be, the resulting machines must be small, compact and strong, capable of being assembled and disassembled simply and quickly. They must stow in a small space, must be easily handled for launching and hoisting in, even under unfavorable conditions of weather, and must be fitted to withstand the severe strains incident to landing on rough water and riding out a gale if necessary. These requirements are radically different from those involved in the design of land planes and far more difficult of realization. They account fully for the backwardness of naval, as compared with military and commercial aviation.

The principal fields of Naval Aviation are *Scouting, Bombing,* and *Spotting* (Fire Control).

In *Scouting,* sea-planes, sent out either from individual fighting ships or from specially designed "Sea-Plane Carriers" accompanying the fleet, will cover a wide area of vision, keeping in touch with the commander-in-chief by wireless telephone, and giving notice of the appearance and the movements of an enemy force many hours before contact can be made in any other way. Attacks by *bombing* will be directed not only against capital ships, but aganist destroyers and submarines. Planes of special types will carry torpedoes to be launched at high speed and from considerable elevation. Finally, *spotting* by air-planes or by captive balloons will make it possible to direct the fire of the heavy guns against targets far beyond the ship's horizon.

CHAPTER II.

THE HULL AND FITTINGS OF A SHIP.

The principal parts of the hull of a modern ship are named below, and the locations of many of them are shown on Plates **6, 7, 8.** These are views of the midship section, bow and stern of a battleship.

The Keel in a large ship is usually composed of the outer keel, the inner keel, the vertical keel, and the middle strake of the inner bottom plating, called the keelson, with their accompanying angle bars. In some merchant ships a vertical outside keel, or bar keel, is fitted. At its forward end the keel joins the *stem,* which is of great strength, and at its after end joins the *stern-post,* also very strong and arranged to carry the *propellers* and *rudder.*

To the keel are attached the *frames,* built up of main frame bars, floor-plates, and reverse-frame bars, all of which are strengthened and stiffened by *longitudinals* of various types. To the framing, the outside or shell plating is secured, the *garboard strakes* being adjacent to the keel plates and the *sheer strakes* being adjacent to main or upper deck beams.

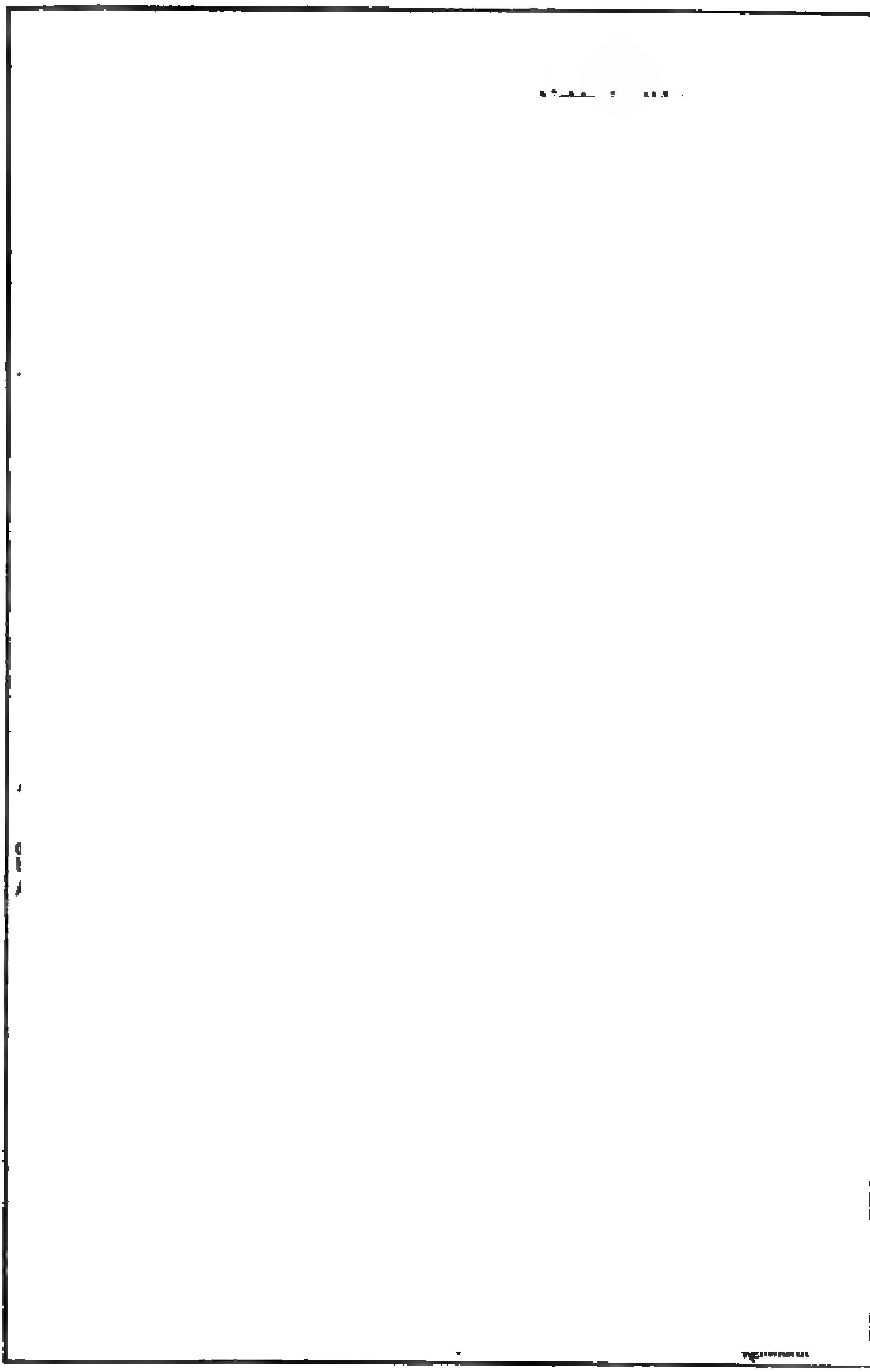
An *inner bottom* is fitted on all large ships; this extends up the ship's side to the armor shelf on armored ships, and to the margin plates on other vessels.

It is subdivided into small compartments by water-tight floors and longitudinals, so that leakage is reduced to a minimum if the ship touches bottom. The frames near the bow and stern are sometimes spaced more closely than elsewhere to provide local strength, and *breast hooks, panting stringers, transom plates* and *counters* are fitted for like reasons.

Bulkheads are used to vertically subdivide the ship's interior into water-tight compartments for the preservation of buoyancy and stability; oil-tight bulkheads are fitted to form the necessary fuel oil tanks, and non-water-tight bulkheads are fitted to provide stowage and living spaces where water-tightness is not essential.

Decks are used primarily to provide shelter, working spaces and living quarters; and secondarily to horizontally subdivide the

Plate No. 6.



MIDSHIP SECTION OF A BATTLESHIP

BOW OF A BATTLESHIP.

Plate No. 8.

STERN OF A BATTLESHIP.

hull into a still greater number of water-tight compartments. Those used for the latter purpose are of steel, and may or may not be covered with planking or linoleum. Other decks may be planked and calked only; but in this case, deck stringer plates and tie-plates are used to stiffen the deck beams. Deck beams are supported by stanchions, giving the decks support additional to that afforded by the bulkheads, and are fastened to the frames by means of beam arms or beam knees. In addition to providing subdivision, decks are absolutely necessary to ensure the ship's structural strength, both longitudinally and transversely. (For Nomenclature of Decks, see Appendix.)

To secure accessibility to all parts of the ship, numerous hatches, doors, scuttles and manholes are provided; these are water-tight where necessary, and those on the upper decks are always fitted for *battening down* to prevent the entrance of water to the interior of the ship in the event of the decks being swept by heavy seas.

Fighting Ships are provided with *protective decks* of steel to protect the propelling machinery and other objects below the water-line; and even on gunboats it is not uncommon to find a steel water-tight deck, which assists in preventing loss of stability if the outside plating should be penetrated near the water line.

Ventilation is provided to secure a circulation of air within the hull's interior and to replace foul air by fresh air taken from the outside atmosphere. Natural ventilation is provided by cowls and windsails, which, when trimmed to the wind, send fresh air below to replace foul air which is forced outboard through hatches, air-ports, etc., or through exhaust cowls which are trimmed from the wind to increase the rapidity of air circulation. Artificial ventilation is provided by steam or electric blowers, which drive fresh air from outboard and discharge it through ducts and louvres into the ship's interior; or which draw foul air from the interior and discharge it outboard. In large ships, both of these artificial systems are frequently combined; one set of blowers supplying fresh air, and another set exhausting foul air. In all ships, natural ventilation is extensively provided, and careful attention to apparently small details is necessary to secure efficient circulation.

In modern ships the ventilation is accomplished by means of a

large number of independent systems so distributed that watertight bulkheads are seldom pierced by the piping.

Earlier ventilation systems provided cold air only. Later ships are equipped with combined heating and ventilating systems for living spaces.

Coal Bunkers must be ventilated on account of the gases formed in them, which, when mixed with air, may cause an explosion. Exhaust piping is led from the upper part of the bunkers to the smoke-pipe uptakes, and fresh air is supplied from the boiler rooms. In some cases a small exhaust pipe from each bunker is led to the vicinity of the bridge. Smoke escaping from such a pipe would give warning of fire in the bunker.

Drainage. To provide for the removal of large quantities of water from the bilges, the main circulating pumps are provided with bilge suctions and are also usually connected with a main drain pipe of large size which generally extends from the forward fire-room bulkhead to the after engine-room bulkhead, with suitable valves permitting the inlet of water from any main compartment which is to be drained. In recent battleships, the boiler rooms have independent motor-driven pumps with independent outboard discharges. The pumps are of the centrifugal type and are capable of operating submerged, as the motors for driving them are placed on a higher deck-level than the pumps, and the valves opening into the sea-valves can also be operated from a higher deck.

There is also a *secondary drain* connected to numerous pumps, which enables small quantities of water to be removed from any compartment in the following manner: A metal chest called a *manifold,* containing a number of suitable valves, is located in a convenient position. One of these valves is connected by piping to an adjacent pump, another to the secondary drain, another to the sea, and each one of the remainder to some particular compartment above or within the double bottoms. To remove water from any compartment containing water, it is only necessary to open the valve connecting the compartment with the manifold, and the valve connecting the manifold with a convenient pump, and then to operate the pump.

The Firemain usually consists of a lead-lined steel pipe running fore and aft nearly the whole length of the ship, and placed, on

warships, underneath the protective deck. It is connected to the fire and bilge pumps and is maintained full of water at a pressure of one hundred pounds per square inch. Numerous branches are located in suitable positions on the various decks, to which are attached hose plugs to furnish water for fire and wash-deck purposes. On recent warships the various upper outlets are connected by vertical branches or risers to the firemain below the protective deck, each having a stop valve by which it may be cut off from the rest of the systems; so that any one set of outlets may be disabled without disabling the others. Fire hose ready for instant use is stowed near each plug. Branches from the firemain are frequently led into the coal bunkers for use in extinguishing fires caused by spontaneous combustion. The salt water required for flushing the heads and lavatories is sometimes supplied from the firemain direct, and sometimes by a separate system of flushing pipes which are filled by certain special steam and hand pumps.

The **Sanitary** and **Flushing System** provides a supply of salt water for use in toilets, washrooms, laundries, galleys, ash chutes, sick bay, etc. In a battleship, the *flushing main* is about six inches in diameter and is carried underneath the second deck beams, being supplied by risers from the sanitary pump and cross-connected to the fire and bilge pumps. Branches as required lead to the various compartments. The crew's lavatories on recent large battleships are often flushed by an independent system supplied by motor-driven pumps.[1]

Fresh Water for use in the boilers and for drinking purposes is carried in steel tanks which can be filled from shore, from water boats, or from the ship's own distillers. For a battleship with a crew of 1,000 men, the capacity of the evaporating and distilling plant is about one hundred tons of fresh water every twenty-four hours.

Magazines are flooded when necessary through pipes connected to the sea, one or more flood cocks being provided in each ammunition room, so arranged that they can be opened from the handling space and also from an upper deck.

Propellers for warships (Plate 9), are generally of the three-

[1] See Appendix for "Pumps and Their Uses."

Plate No. 9.

STERN OF A BATTLESHIP.

bladed type, while for merchant ships, four blades are generally used. The three-bladed propeller is lighter and of higher efficiency, but many engineers prefer the four-bladed propeller on account of the reduced tendency to vibration in rough water. Propellers for high speed turbine installations are characterized by their small diameter. Propellers are now ordinarily made of manganese bronze, as more strength and a much better surface can be obtained with this material than with cast-iron or cast steel. When bronze propellers are used, however, it is generally necessary that zincs be fitted to the ship's hull in their vicinity to prevent galvanic action upon the steel of the hull.

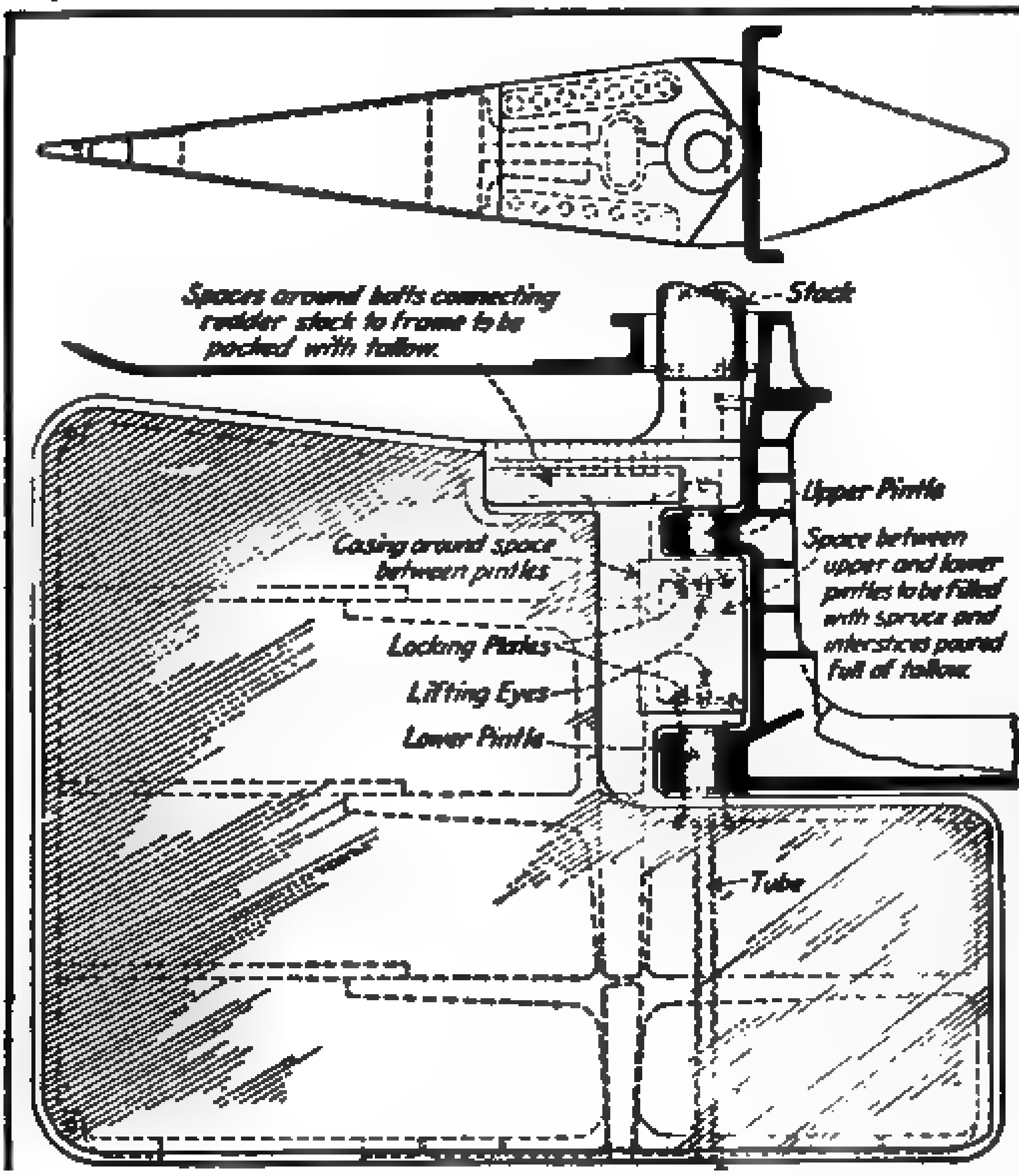
The *Propeller Struts* are used for supporting the propeller and tail-shaft outside the hull, and in recent ships are of pear-shaped or oval section to diminish the resistance to their passage through the water. In addition to having this shape of section, the longitudinal axes of the strut-arms are placed in the path of the stream-lines at the stern of the ship, to still further decrease their resistance.

Steering Gear. The *rudder* of a warship (Plates 9 and 10) is unusually large and the steering gear unusually strong, in order that such a vessel may be under more perfect control than is considered necessary in merhantmen. The *rudder-stock* is made of special forged steel, its size depending upon the speed and size of the ship and the rapidity with which it is necessary to put the helm hard over when the ship is at her maximum speed. The *rudder-frame* is usually of cast steel, which is filled in with wood and covered with steel plating. On most ships, the weight of the rudder is taken on a suitable carrier within the ship, firmly supported by the hull structure and so arranged that the stuffing box and gland attached to the rudder-post casting may be accessible. (Plate 9.)

The *rudder* is attached to the *stern-post* by "pintles" and "gudgeons" in such a way that it can be unshipped in drydock. The pintles are forged pins on the forward edge of the rudder. The gudgeons are the lugs on the after side of the stern-post into which the pintles are engaged.

Rudders may be either *balanced* or *unbalanced,* the balanced type being used principally on men-of-war, the unbalanced on merchant vessels. When a balanced rudder is put over, the water

Plate No. 10.



UNSHIPPING OF RUDDER.

1. Remove casing around space between pintles and turn hard over.
2. Remove filling, locking plates, & lifting eye from lower pintle.
3. Drive down upper pintle (thru hole in stock) and support same by blocking when attaching sling for removal.
4. Reinsert lifting eye in lower pintle, remove cover plate, and drive up lower pintle thru tube provided for this purpose. When raised about 9" remove eye bolt, and raise and remove by sling fitted around exposed part of pintle.
5. Block up rudder, and remove upper bearing and stuffing box on sternframe after dismounting crosshead, etc.
6. Swing rudder aft as far as possible and lower at the

pressure on the part forward of the rudder-post acts with the tiller and greatly reduces the power required to put it over and to hold it in position. (Plates **9, 10.**)

To the *rudder head,* the *rudder cross-head* or the *tiller* is firmly secured. Sometimes both are fitted.

It frequently occurs that the run of the ship is so fine that it is necessary to fit a secondary cross-head placed further forward, in order to provide space for the steering gear and its connections, the two cross-heads being connected by suitable rods. It is not uncommon, where space permits, to use a straight tiller or quadrant which is connected to the steering mechanism by chain or wire rope. The rudder is thus turned through an angle of about 35 degrees on each side of the centre line, hard-over stops being fitted to the rudder post and the rudder frame to limit the amount of travel should accidents occur to the steering mechanism. The motive power is usually steam, hydraulic or electric, hand power being always provided for use in cases of complete breakdown.

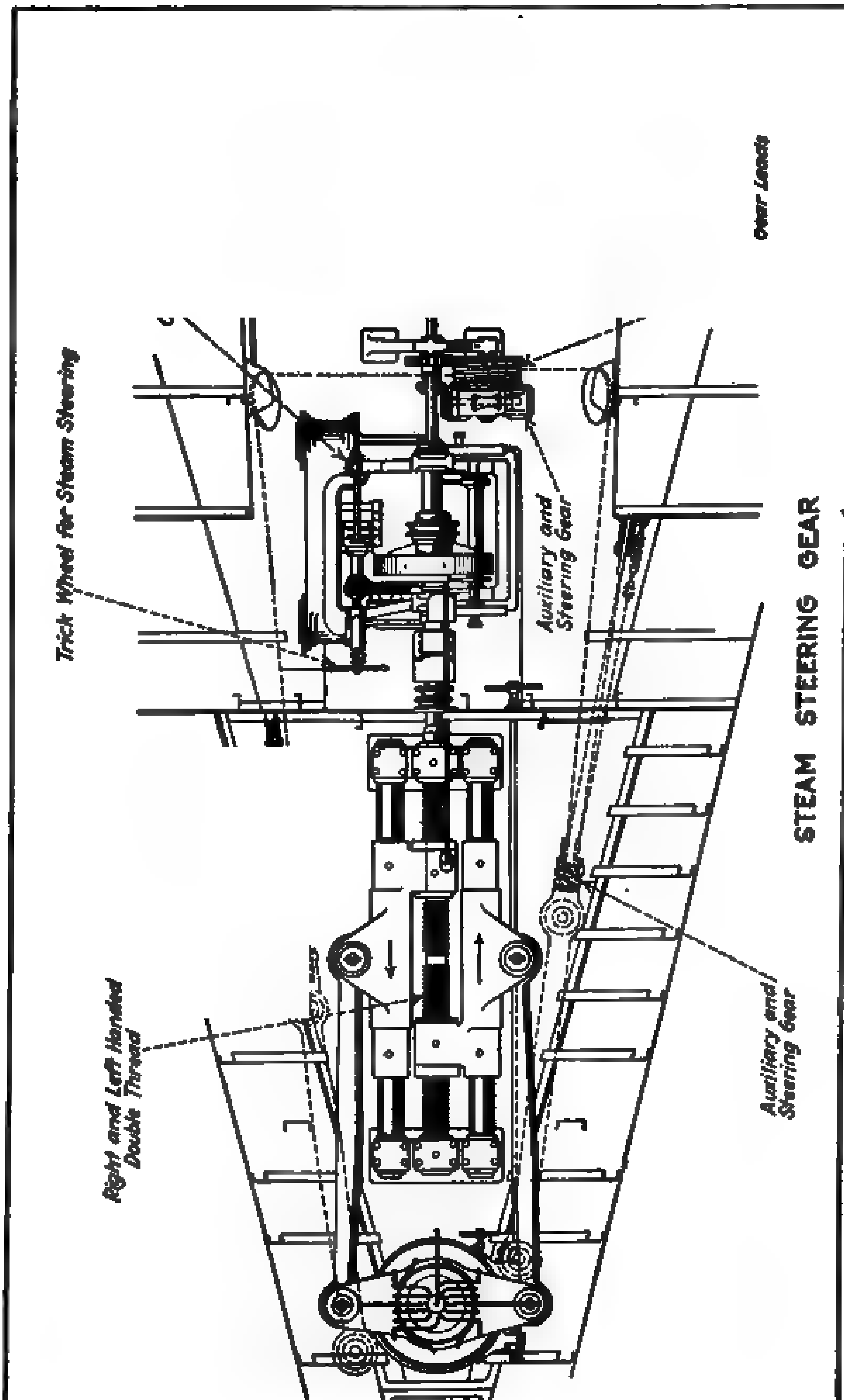
Where a rudder cross-head is used (Plate **11**), the engine turns a shaft having a right and left-handed thread which drives two nuts connected to the cross-head by side rods. By turning the engine in one direction the nuts recede from each other and the cross-head turns in one direction, and by turning the engine in the reverse direction, the nuts approach each other and the cross-head is turned in the reverse direction. When hydraulic power is used, the side rod from each side of the cross-head connects with a suitably guided piston rod, having a piston within a cylinder, each end of which permits the entrance of water at high pressure, and also its exhaust. By admitting water at the forward end of one cylinder and the after end of the other while at the same time opening the exhausts at the opposite ends, the cross-head is turned in one direction, and will be turned in the opposite direction by reversing the operation.

With quadrants and tillers, the chain or wire rope is wound around a drum which can be turned in either direction, suitable provisions being made to prevent any slack occurring.

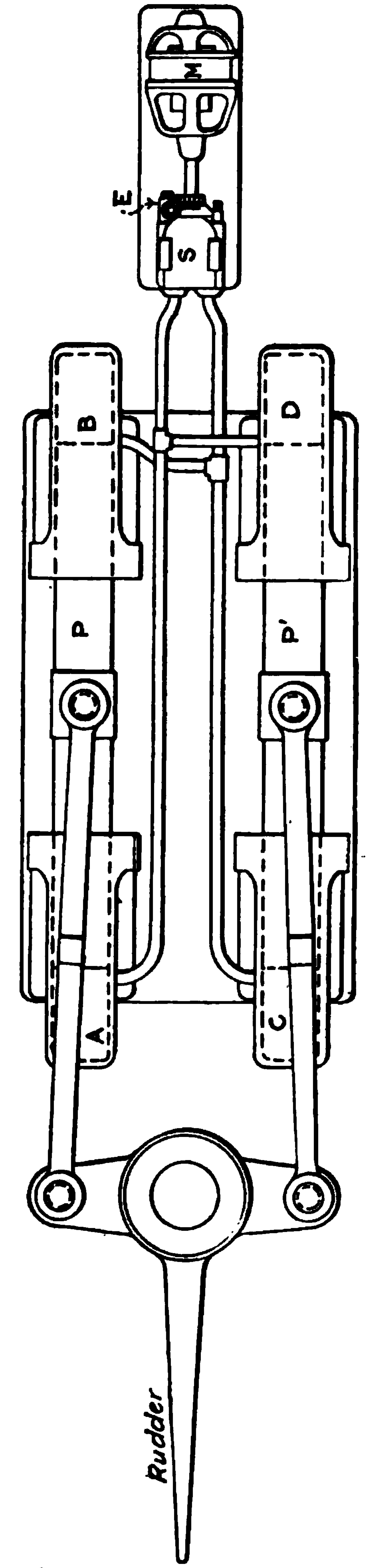
The hand gear consists of steering wheels of large size located in various parts of the ship, which by shafting, chain, or wire-rope, operate the rudder in the manner shown on the plans.

Arrangements are provided for shifting quickly from power to hand gear, and from hand to power.

Plate No. 11.



STEAM STEERING GEAR



DIAGRAMMATIC PLAN OF MAIN STEERING GEAR
U.S.S. NEW MEXICO

Steering wheels are usually provided in the conning-tower, in the "Central Station," and on the bridge; and where practicable are arranged with clutches so that any one wheel can be turned without turning the others. From the conning-tower stand, a steel rod extends downwards through the armored tube and below the protective deck, where it rotates a transmission drum, which in turn rotates a second drum located in the steering room, the two being connected by the steering rope. The valve controlling the admission and exhaust of steam or water is automatically operated by the transmission drum so that the rudder is turned whenever the helmsman turns the power steering wheel, and remains stationary at any angle when the wheel is kept stationary at the corresponding position, the helm indicator showing at each instant the actual position of the helm. Various electric and hydraulic appliances are also used to accomplish these same purposes.

The application of electricity has passed beyond the experimental stage, and in recent ships the steam steering engine is replaced by an electric motor. In the very latest dreadnaughts, the power used for steering is electro-hydraulic.

ELECTRO-HYDRAULIC STEERING GEAR.

The electro-hydraulic steering gear which is being installed on the latest vessels consists essentially of a hydraulic steering gear of the usual type which takes its supply of operating fluid from a variable stroke pump connected to a continuously running electric motor, instead of taking its supply from a constant pressure source, such as the ship's hydraulic mains or an accumulator supplied by steam pumps.

Plate 12 shows the principles of operation. Two hydraulic plungers P and P′ have connecting rods to the rudder cross-head and operate in double opposed hydraulic cylinders A, B, C, and D. The cylinders are connected by piping to a variable stroke pump, S, operated by a continuously running electric motor M. It is seen that if the operating fluid (oil) is pumped out of cylinders A and D and into cylinders B and C the rudder will be moved to starboard; and correspondingly if pumped from cylinders B and C into A and D the rudder will move to port.

The pump S, is the pump end of a Waterbury Hydraulic Speed Gear, which has been used on all late vessels for turret

turning and gun elevating. The amount of oil pumped and the direction of its flow is controlled by a control shaft E. When the control shaft is in its neutral position no fluid is pumped, when it is turned in either direction from neutral the flow is in a corresponding direction, and the amount of oil pumped is proportional to the amount the control shaft is moved from neutral. Thus the control shaft performs all the functions of the reversing valve ordinarily used on hydraulic steering gears, and by turning it the rudder is moved. The speed of the rudder is proportional to the amount the control shaft is moved from its neutral position, and when the control shaft is at neutral the rudder is held stationary. The control shaft is connected through a follow-up mechanism (not shown in sketch) to a trick wheel and also to some part which moves with the rudder, so that the rudder follows the movement of the trick wheel. Connection between the steering wheel on the bridge and the trick wheel (actually the trick wheel shaft) can be made by any desired method, such as: wire rope transmission, hydraulic telemotor, or electric pilot motor and controller. If either of the first two methods is used there is an actual steering wheel on the bridge with follow-up control between it and the rudder. If the electric pilot motor is used its controller is placed on the bridge and non-follow-up control is obtained of the same nature as the present straight electric steering gears.

The efficiency of the hydraulic cylinders and the variable stroke pump is very high, while the efficiency of the right and left hand screw (usually used with the straight electric steering gear) is very low. Thus the amount of power required is much less with the electro-hydraulic than with the straight electric gear. Also by limiting the amount that the control shaft may be turned when the rudder is nearly at the hard-over position the maximum peak of the power required during the cycle of hard-over to hard-over can be considerably reduced. The combination of these two properties results in a very much less demand on the ship's electric generators when the electro-hydraulic design is used.

The Steering gear for the most recently designed Battleships and Battle Cruisers of the United States Navy (North Carolina and Lexington Classes) will consist of hydraulic rams directly connected to the rudder and operated by motor-driven variable-

stroke-pump equipment, essentially like the gear above described.

The Telemotor is a device for furnishing a connection between the steering engine and the steering wheel, such that the wheel shall not only control the engine but indicate at all times the position of the rudder. In vessels of early design this connection was made by wires, chains, or shafting, with a complicated lead which involved many joints and turns. In the telemotor, the connection is sometimes electrical but more often hydraulic.

In some ships the Telemotor System is doubled throughout so that in case one line of piping is out of commission the other may be used.

The hydraulic telemotor used in battleships of recent design is shown on Plate 13.

Fig. 1 shows the vertical section of a pump, *A*, fitted with the usual piston, *B*, which is moved up and down by a rack, *C*, into which gears a pinion, *D*, the shaft of which is made to revolve by the wheel, *F*, the pinion, *G*, and the hand-steering wheel. The cylinder *A*, when the piston is where shown on the drawing, *i.e.*, in mid-position, admits of a free passage of water above and below the piston, so that there are two cylinders, the upper one and the lower one.

From the by-pass valve, *S*, which is connected to the top of cylinder by pipe *H*, and directly to the lower cylinder, two pipes, *H* and *I*, Fig. 1, pass and join up to a cylinder *K*, Fig. 3. These pipes correspond to pipes *M* and *L*, Fig. 3. The cylinder *K* is fitted with a piston *N* and with the usual piston rod and connecting link *O*, which is attached by a lever to the follow-up mechanism of the steering engine. The piston rod has cross-heads *P* and *P*, between which are two spiral springs *Q* and *Q*. the object being to cause the piston end to fly into mid gear, unless put out of that position by pressure of water on either side.

As the diameter of the cylinder on the bridge is in every respect the same as that aft, it follows that when the apparatus is fully charged with fluid, any movement of the steering wheel will bring about a similar movement of the aft motor-piston and the valve gear of the steering engine. In putting the wheel over, it will be felt to become sensibly stiffer until it is hard over, and on letting it go it will run back of its own accord amidships.

The telemotor on the bridge is fitted with an indicator shown in Fig. 2, which shows the actual position of the helm.

TELEMOTOR.

Plate No. 14.

FIG. 1. THE HEMP PLANT.

FIG. 2. THE ABACA PLANT.
(Manila Fibre.)

FIG. 3. HEMP FIBRE.

FIG. 4. MANILA FIBRE.

ROPE FIBRES.

CHAPTER III.

ROPE.

§ I. FIBRE ROPE.

The rope commonly used on shipboard is of three kinds: Hemp, tarred and untarred, Manila and Wire. Ropes are made also of flax and cotton, but these are not suitable for use at sea.

Full particulars as to rope of all types used in the United States Navy are given in tables in the Appendix, which tables should be consulted in connection with this Chapter.

Much confusion results from the common practice of designating all ropes made from vegetable fibre, as "hemp." This mistake is almost universally made by other than sea-faring people in referring to manila, which is sometimes called "manila hemp," but oftener simply "hemp."

Hemp rope is made of fibres from the stalk of the hemp plant, which is cultivated extensively in many parts of the world, but especially in Italy, Russia and the United States. American hemp is very generally used for cordage in the United States.

Manila rope is made from the fibre of the "abaca," or wild banana, and comes principally from the Philippine Archipelago. As has been noted above, it is commonly designated as "Manila hemp." It has to a great extent displaced the true hemp for general purposes, especially on shipboard.

How wide is the difference between Manila fibre and true Hemp is indicated on Plate **14**, where both the plants and the fibres are contrasted. In spite of this difference and of all that can be said in favor of a more correct nomenclature, Manila rope will doubtless continue to be called "Manila Hemp," but it is desirable that sea-faring men should know the difference, even though they may find it convenient to fall in with the commercial practice of ignoring the distinction.

Rope is sometimes made of Coir ("Kyar"), the fibre of cocoanut husks. This rope is light and permanently buoyant; that is to say, it does not become water-logged. It is thus well suited for running lines over water, and while only about half as

strong as Manila, is strong enough for hauling-lines and might well be supplied to ships for that purpose, in sizes of three inches or thereabouts.

In the manufacture of rope from the original fibres, the fibres are twisted into *yarns,* which in turn are twisted into ***strands***. A number of strands are twisted into a ***rope*** and sometimes several ropes are twisted into a *cable*. Plate **15**, Fig. 3.

The fibres of the hemp or manila having been separated by appropriate mechanical processes from the woody matter with which they are associated in the plant, are inspected, graded as to quality, and baled for shipment. At the factory, they are passed through processes of carding and spinning from which they emerge as long yarns, wound on bobbins. The yarns are twisted into strands and the strands into ropes, by machinery of the general character illustrated in Plate **16**.

The individual fibres of manila have a tensile strength of approximately 30,000 lbs. to the square inch. Something of the strength is lost by the twisting processes of manufacture but the twisting reduces the tendency of the fibres to slip, one upon another, and in this way adds to the strength of the rope as a whole. It adds also to the *elasticity* of the rope, giving it, in fact, something of the character of a spiral spring.

To counteract the tendency to unlay, the successive twists are taken in opposite directions; yarns being usually right-handed, strands left-handed, ropes right-handed, and cables left-handed. The above rule may be reversed, producing "left-handed" or "back-handed" rope.

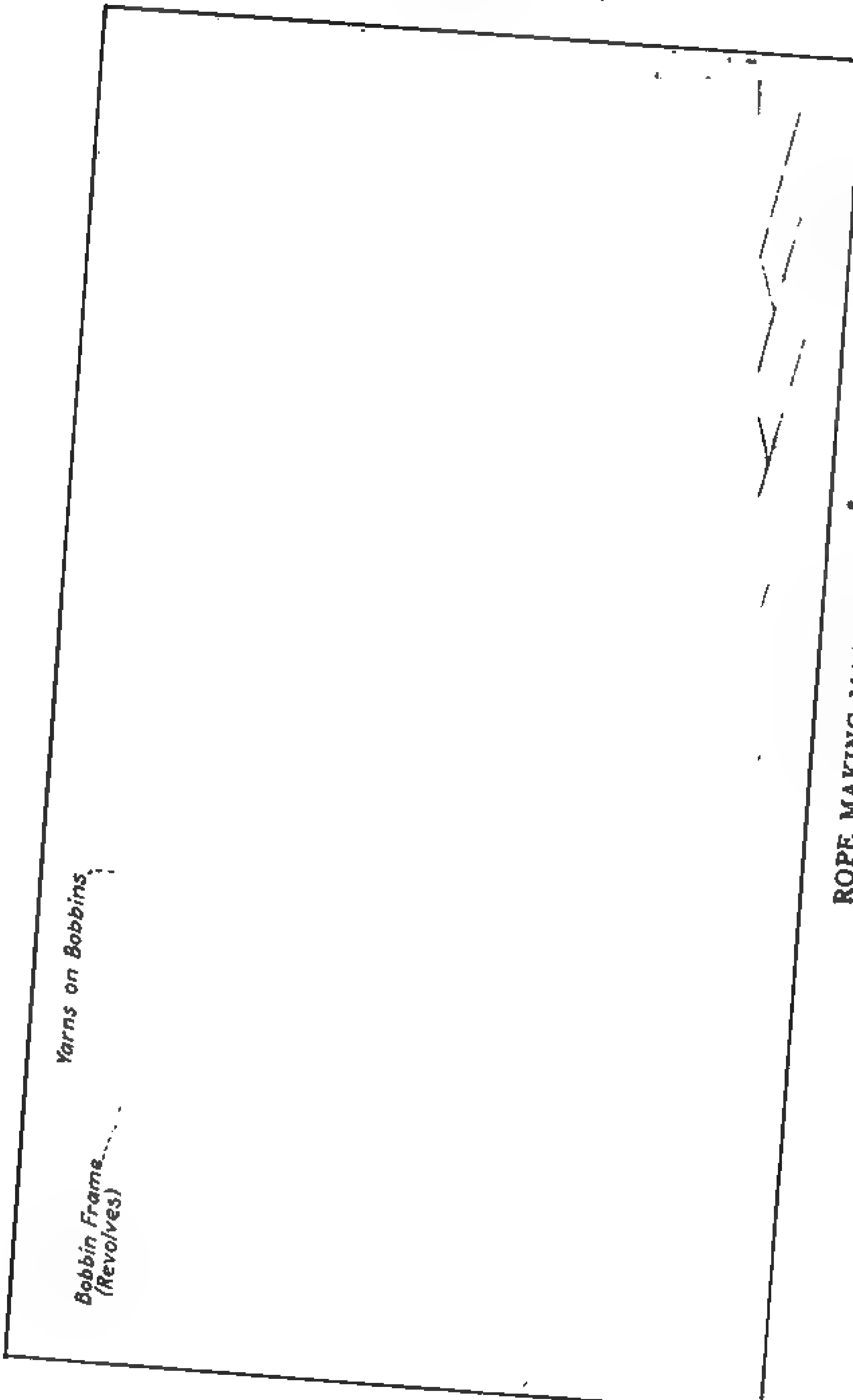
Rope is commonly made with three strands, but four are sometimes used.

Hemp Rope is now but little used. When used it is almost invariably tarred. In this form it is used on shipboard for such of the standing rigging as is not of wire and for the heaviest of the running rigging of sailing ships. The tar preserves the rope from deterioration due to dampness but reduces its strength and flexibility. Untarred hemp is the strongest rope made except wire.

In present United States Naval practice, hemp is used only for "small stuff":—roundline, houseline, etc., all rope larger than "24 thread stuff" (1¾ inch circumference) being made of *Manila.*

MANILA ROPE.

Plate No. 16.



ROPE MAKING MACHINE.

Both the manila rope and hemp rope of commerce vary greatly in quality. At their best, both should show a smooth, even surface when laid up, with few projecting ends of the fibres. When unlaid, the strands should show long and glossy, without admixture of short ends or "tow."

For special purposes, rope is sometimes plaited instead of laid. This does away with the tendency to kink.

Fibre Rope is designated as to size by its circumference, and runs from about three quarters of an inch to sixteen inches and even more; but the largest sizes are never seen on shipboard, twelve inches in manila and seven inches in wire being about the maximum that even the largest ship would carry. The length is measured in fathoms of six feet each. For shipment it is made up in coils. (Plate 15.)

Small cordage is usually known on shipboard as "small-stuff," and designated either by the number of threads that it contains, as "18-thread stuff," "15-thread stuff," etc.:—or as "Ratline stuff," "Seizing stuff," "Marline," "Spun-yarn," etc. These are usually of American hemp, tarred, and are measured in some cases by the fathom, in other cases by the pound.

The following are the most common varieties of small-stuff used on shipboard.

Spun-yarn. A rough and comparatively cheap stuff made from long tow and loosely laid up, left-handed, of two, three or four strands. It is more used on shipboard than any other variety of small-stuff, being convenient for seizings, service, etc., where great neatness is not required.

Houseline, Roundline and **Marline** are used for the same purposes as spun-yarn, but make neater work, being laid up more smoothly and of better material.

Marline is 2-stranded left-handed, **Houseline** 3-stranded left-handed, and **Roundline** 3-stranded right-handed. All of the above are used for seizings, but where a heavier and stronger material is needed, a higher grade of stuff is used, laid up by rope-making machinery and finished like the larger sizes of rope, although classed as small-stuff. This is called **Seizing Stuff.** It is usually 3-stranded, right-handed, and may have 2, 3 or 4 threads to the strand, making 6-thread, 9-thread or 12-thread seizing stuff.

Ratline Stuff does not differ from seizing stuff in its general

characteristics, but is larger. It is 3-stranded, right-handed, and may have 4, 5, 6, 7 or 8 threads to the strand, making "12-thread," "15-thread," "18-thread" Ratline Stuff, and so on.

Rope-yarns are used for many purposes on board ship, and a good supply of them should always be on hand. They are made by unlaying condemned hemp cordage, tarred.

Two yarns twisted up together by hand, or single yarns twisted up against their natural lay and rubbed smooth, are called "foxes" and are often used for light seizings, being much neater than spun yarn. (For further details as to Cordage, see Appendix.)

Rope tends to contract when wet, and unless allowed to do so freely may be injuriously strained. It is for this reason that running gear is slacked in damp weather. On the other hand, advantage may be taken of this tendency for tautening lashings, etc., by wetting the rope.

As rope deteriorates rapidly from continued dampness, it should never be stowed away unless perfectly dry. This caution is especially important in the case of hawsers, which are rarely used without being wet. It is a reason also for the rule that hemp and manila should not be covered except when absolutely necessary, as the covering not only holds the moisture but prevents the deterioration from being seen.

Unlike the metals and other similar substances, rope made of vegetable fibre has not a permanent elastic limit within which it may be worked indefinitely without injury. Owing to the tendency of the fibres to slip one upon another in spite of the twist, the rope gradually loses its cohesion under repetition of very moderate tensions, and may be seriously weakened by constant working, without ever having been subjected to anything approaching a breaking stress; while if subjected even once to a stress approaching that of breaking, its strength is permanently reduced and it may be expected to give way under a very moderate pull.

While the thought of **lubrication** is not usually associated with the thought of hemp or manila rope, it is a very important factor, making for preservation as against both excessive dampness and excessive heat. From eight to ten per cent. by weight of the finished rope consists of oil, which is sprayed upon the fibres before the process of manufacture begins.

§ II. WIRE ROPE.

Wire rope (Plate 17) is made of steel or iron wires laid up like yarns to form strands, which strands are in turn laid up to form a rope. The characteristics of the wire and the manner of making it up vary within wide limits in accordance with the purpose for which the rope is intended. Where great flexibility is wanted, as in the case of rope to be worked over pulleys, this quality is secured at some sacrifice of strength. Such rope should not be galvanized unless it is to be exposed to the weather or to extreme dampness. Where a steady stress is to be provided for, as in the case of standing rigging, the tensile strength is of maximum importance; and in this particular instance (standing rigging), galvanizing is essential because of the necessary exposure to weather. The number of strands will depend upon the purpose for which the rope is designed, as will also the nature of the heart. As a rule, six strands are used, laid up around a hempen heart. The number of wires to a strand varies widely but the two most commonly used types consist of 6 strands of 19 and 37 wires to the strand. In both of these types, known as the "6x19" and the "6x37" types, the strands have wire hearts and the rope a hemp heart. Approximately 75 per cent. of the wire rope used in the United States is of the 6x19 type, this being considered to give the best all-around combination of qualities and the best balance of strength and flexibility. Where greater flexibility is required, the 6x37 type should be selected, or the 6x24; or, if strength is not important, the 6x12. Both the 6x24 and the 6x12 types have a hemp heart for each strand as well as for the rope. (Figs. 1, 2, 3, 4, Plate 17.)

The use of hemp for the heart of the rope not only contributes to flexibility but has the further advantage that the hemp forms a cushion upon which the strands close in as the rope contracts under a heavy pull, thus acting with the elasticity of the wire and the "give" which results from the spiral lay, to reduce the effect of sudden stresses. If it happens that the hemp heart has absorbed its share of the lubricant which should be used upon the rope from time to time, this cushioning will result in a lubrication of the interior wires and greatly reduce the interior friction.

Manufacturers commonly designate the size of wire rope by the *diameter* and this designation is used in circulars and in specifications of the United States Naval authorities; but sea-

men adhere to the habit of designating it, like Hemp and Manila, by *circumference.* This difference sometimes leads to confusion, but as the ratio of circumference to diameter is approximately 3 to 1, no serious misunderstanding is likely to result as to the size of rope referred to in any individual case. It is well, however, to take the precaution of stating whether the size mentioned represents diameter or circumference. (See method of measuring diameters in Plate 18.)

Galvanizing is the simplest and most efficient means known for preserving wire from corrosion, but it involves exposing the wire to a high temperature, which reduces the strength by something like 10 per cent. The process of galvanizing consists of drawing the wire slowly through a bath of molten zinc, from which it takes on a thin but very tenacious coating, sufficient to protect it from the corrosive action of moisture. Such protection is especially important for wire which is to be exposed to salt water.

As a general rule, galvanized rope should not be used for working over sheaves except in cases where the sheaves are large and the motion slow. Under other conditions—sheaves small or motion rapid—the zinc coating wears off in a short time, frequently breaking and peeling, and corrosion at points thus exposed to moisture, *and especially to salt water,* proceeds more rapidly (through electrolytic action) than if no zinc were present.

Wire rope, *galvanized,* is used for the standing rigging of ships, and for spans, slings, ridge-ropes, topping lifts, guys, etc. It is used also for running gear in special cases where exposure to weather is involved and where the sheaves are large; as in single pendants and in the slow-running tackles of cranes.

Wire *hawsers* are always galvanized.

Wire rope *ungalvanized* is used for a great variety of purposes, especially for work over sheaves comparatively small, and for general work, without reference to the size of sheaves, in places where no excessive exposure to moisture is involved.

Where there is a conflict between the rules laid down as to the use of galvanized and ungalvanized rope, it will not usually be difficult to decide which rule should prevail.

It will be clear from what precedes, that the suitability of a rope for any given purpose depends not only upon its strength but upon several other qualities. For many purposes, flexibility is more important than strength. In cases where much wear is in-

volved, it is desirable that the individual wires should be fairly large, so that the outside wires shall not wear through too quickly. For standing rigging, a wire core is admissible, while for running rigging of all kinds, a hemp core is absolutely necessary. If a rope is to be exposed to the weather it must be galvanized; otherwise, not.

It is important, in ordering wire-rope, to specify the purpose to which it is to be applied and as many of the conditions of its use as practicable.

Plate **17** shows various types of wire rope suitable for different purposes. As a rule these types are made in the following grades of material, with tensile strength *in the wire used,* approximately as indicated.

1. Wrought iron, 85,000 lbs. per square inch.
2. Crucible Cast Steel, 150,000–200,000 lbs. per square inch.
3. Extra Strong Crucible Cast Steel, 180,000–220,000 lbs. per square inch.
4. Plow Steel, 200,000–260,000 lbs. per square inch.
5. Monitor Steel, 220,000–280,000 lbs. per square inch.

The types illustrated are those specified for use in the United States Navy but they are standard commercial types and cover practically all the demands of seafaring practice in general and all but a few highly specialized demands of industrial practice on shore.

Naval specifications call for a *minimum* strength in all types, of 220,000 lbs. per square inch in the wire from which the rope is made. The grades used are 3 and 4 above.

6 × 19 Type (Fig. 1). This is the stiffest and strongest type manufactured for use on ship-board. It is especially suitable for standing rigging, guys, boat slings, topping lifts, etc. It may be used over sheaves of large diameter where the speed is moderate, but has not the flexibility required for running rigging in general.

This type is issued to the Navy both galvanized and ungalvanized.

6 × 37 Type (Fig. 2). This type combines strength with flexibility to a degree which makes it especially valuable for work on shipboard. It is much more flexible than the 6 × 19 type and much stronger than the 6 × 12 or the 6 × 24 type. It may be used over sheaves smaller than those for which the 6 × 19 type is practicable, and is especially suitable for cranes and other machines where sheaves are necessarily rather small and where heavy weights are to be handled.

It is the best rope for heavy towing, whether with or without an auto-

Plate No. 17.

WIRE ROPE UNLAID, SHOWING HEMP CORE.

TYPES OF WIRE ROPE.

matic towing machine. When designed for towing it is galvanized and should be fitted with a thimble eye at each end. As more than 50 per cent. of the wires in a strand are on the inside, it follows that the outer wires may be considerably worn before the strength of the rope as a whole is seriously impaired.

This type is issued to the Navy both galvanized and ungalvanized.

6 × 12 Type (Fig. 3). This is the most flexible rope made for ordinary purposes, but has only two thirds the strength of the 6 × 19 and 6 × 37 types. It is used for most of the running gear which is made of wire (except as already specified for the 6 × 37 type) and for life-lines, guys, ridge-ropes, etc. It is used also for mooring hawsers in cases where no great strength is required. It is sometimes used for towing but is *not recommended* for this unless with an automatic towing machine, and not then for heavy work.

6 × 24 Type (Fig. 4). This type, while inferior in strength to the 6 × 37 type, resembles the latter in that it represents a convenient balance of strength and flexibility. It is designed primarily for mooring hawsers to be used where greater strength is needed than that of the 6 × 12 type. It has also an advantage over the latter in that it is better fitted to stand the abrasive effect of snubbing through chocks and around bollards, because 30 per cent. of its strength is in the inside layers of its strands.

Armored Wire Rope (Fig. 5). In this type each strand is wrapped spirally with flat strips of steel which protect the wires from abrasive wear. The wrapping contributes nothing to the strength of the rope but by deferring the time when the strands begin to wear, prolongs the life of the rope in some cases by as much as 50 to 75 per cent. The increase in weight and the reduction of flexibility are unimportant.

Fibre Clad Rope (Fig. 6). In this type each strand is served with tarred hemp marline, which protects the wire from wear and from corrosion. It has about one-third the diameter of Manila rope of the same strength and is only slightly less flexible; admitting of coiling, belaying, and knotting, without danger of kinking. This makes it suitable for running rigging, especially for boat and crane falls, anchor gear, etc.

The Manufacture of Wire Rope. The manufacture of wire rope follows closely the process already described for fibre ropes, the individual wires corresponding with the *yarns* of hemp and manila. The wires are twisted into strands and the strands into rope, by methods which do not differ materially from those illustrated in Plate 16.

The wire used for rope is made from special ores, which are reduced by the open-hearth process to eliminate as thoroughly as possible all traces of sulphur and phosphorus, both of which impurities make for brittleness. In the various processes which follow, the metal is subjected to carefully controlled heat-treat-

ments and is finally drawn down, cold, to the desired size, after which it is subjected to bending and torsional tests, and tests for elongation and tensile and elastic strength. It is also carefully examined, visually, foot by foot, to make sure that it is free from surface defects. It is the fact that these tests can be made, and are made, upon every individual wire entering into the finished rope, which gives to wire rope its most valuable characteristic, *reliability*.

Notes on Wire Rope.

Wire rope needs in some ways better care than hemp or manila and far better care than it generally receives on shipboard. It should be kept on a reel when not in use. A single kink in the finest wire rope practically ruins it at once.

In receiving a line and transferring it from one reel to another care should be taken to unreel it, instead of slipping off the successive bights over the end of the reel, as is sometimes done.

Plate 18 illustrates the right way and the wrong way of dealing with wire rope under various conditions.

A wire hawser should be gone over thoroughly every month or two with linseed oil; or, better, if it is not to be used for some time, with crude petroleum or some heavy lubricating oil to which a small quantity of lampblack has been added. If the lubricant used is inclined to be stiff, it is better used hot. Neither oils nor tars can be regarded as perfect preservatives, as they all contain more or less acid, which attacks the steel. The principal reliance must therefore be upon the galvanizing. If the rope is to remain under water for some time, the best preservative is made by adding to one part of Stockholm tar, one part of fresh slaked lime. Boil well and use while hot for saturating the rope.

It is important that the lubricant, whatever its composition, should be thin enough to penetrate into the interstices of the rope and yet that it should have consistency enough to adhere to the wire for a reasonable length of time, after which it should be renewed. Care must be taken to insure covering the rope all around. A hawser used for towing should be relubricated after use while being reeled up.

Wherever wire rope is to be worked over a sheave, the diameter of the sheave and the speed of running become very important factors. The larger the sheave and the lower the speed, the

Right Way (U-bolt on Dead End).

Wrong Way (U-bolt on Tension End).

WIRE ROPE CLIPS,

HANDLING WIRE ROPE.

better. All manufacturers of wire rope prescribe a minimum diameter for sheaves, and their guaranteed breaking strains and estimated safe-working loads are for these minimum diameters, and for moderate speed. A high speed increases the wear upon the rope, not only by the friction on the pulley but still more by the friction of the wires upon each other—a point which is often overlooked.

The importance of this interior friction will be realized if we consider the "play" which necessarily goes on between the fibres of a rope which is being alternately bent and straightened in running over a pulley. This play of course increases with the speed and is greater with a small sheave than with a large one. The same consideration enters in where a rope is alternately stretched and relaxed under a straight but varying pull; as, for example, in towing. This emphasizes the importance of interior lubrication.

The diameter of the sheave over which the rope is worked should never be less than twenty times that of the rope itself; and the less flexible the rope the larger should be the sheave. (See § II, Chapter VII.)

It is important that the score of the sheave should be of such size as to carry the rope without excessive play, and, above all, without friction against the sides of the score. Metal sheaves should be lined with wood or leather.

The turns of the rope should never be allowed to overlap on the drum of the winch.

As the wear of a rope over a pulley increases more rapidly with the speed than with the load, it is better, when an increased output is demanded, to increase the load than to increase the speed.

In addition to the question of *friction* in running over a sheave, the distortion of the rope wherever it passes around a relatively sharp bend, whether on a moving sheave or on a stationary chock or bollard, is a factor of great importance. Those fibres which lie farthest from the centre of the curve are stretched, while those which hug the round of the bend are more or less compressed. Thus the outer fibres may give way before the inner ones begin to feel the strain.

By far the most unfavorable conditions to which wire rope can be subjected are those in which it runs over pulleys which give it a reverse bend, like the letter *S*, such that it passes over

one pulley with a bend to the right and immediately afterward swings around another with a bend to the left.

While the strength, lightness and durability of wire rope are important factors in its favor, its most valuable characteristic, as compared with hemp, manila, and chain, is its reliability. Within its proper working limits, it almost never fails. Hemp and manila may be rotten at the core and show no sign, or they may have been weakened by excessive strains and give no indication of it except, perhaps, that they are a little "long-jawed." A chain may be made of worthless material, or, if of the best material and made with every care, it may have flaws which no inspection can reveal.

Hemp and manila ropes are made up of a great number of fibres from a few inches to several feet in length. Wire rope is made of small numbers of wires of the full length of the rope, each of which is manufactured, inspected, and tested, *individually*, throughout its full length before it goes into the rope. The inspection is so simple that a flaw can hardly be overlooked and it is most improbable that any number of wires can have flaws which in the end appear at the same point of a strand. Thus it is almost impossible that any serious flaw should exist in a wire rope as manufactured.

A flaw due to kinking can always be seen.

An accident with wire rope is almost necessarily due to carelessness.

Assuming the rope to have a well-lubricated hemp core, and to be used over properly proportioned sheaves, the outside strands will be the first to wear out, and the reduction in their diameter becomes the measure of the wear of the rope as a whole.

Wire rope should be condemned when the outside wires are worn down to one-half their original diameter, or when it is apparent from broken wires or other abnormal indications that it has been subjected to danger or by excessive strains, or to a sharp bend resulting in a pronounced kink.

When wire rope is to be cut, a whipping of small soft (annealed) iron wire should be wrapped on each side of the point where the cut is to be made, to prevent the rope from unlaying. If suitable annealed wire is not available, a fairly heavy *seizing stuff* may be used, the turns being passed very taut.

CHAPTER IV.

KNOTTING AND SPLICING.

The art of working in rope cannot be learned from a book, but the illustrations which accompany this Chapter will give an idea of the most common knots, splices, etc., in general use and should be helpful up to a certain point in making them.

WORKING IN HEMP AND MANILA.

Plate 19. This plate shows a number of simple knots all of which are made with the end of a single rope.

An Overhand Knot. Fig. 1. This is the simplest possible knot and is the beginning of many of the more complicated knots, bends and hitches which follow.

A **Bowline.** Fig. 2. One of the most common and useful knots known to seamanship. It forms a loop, which may be of any length and which cannot slip, as the heavier the pull upon it the tighter it jams. Moreover, it does not form so sharp a nip as to weaken the rope. It is used for lowering men over a ship's side, for slinging them from stays, etc., while working aloft, and for a great variety of similar purposes. A common use of it is to form a loop in the end of a hawser to be thrown over a bollard, in working a ship alongside a dock.

A **Running Bowline.** Fig. 3. A convenient form of running loop. The loop of the bowline proper is usually smaller than that shown in the figure.

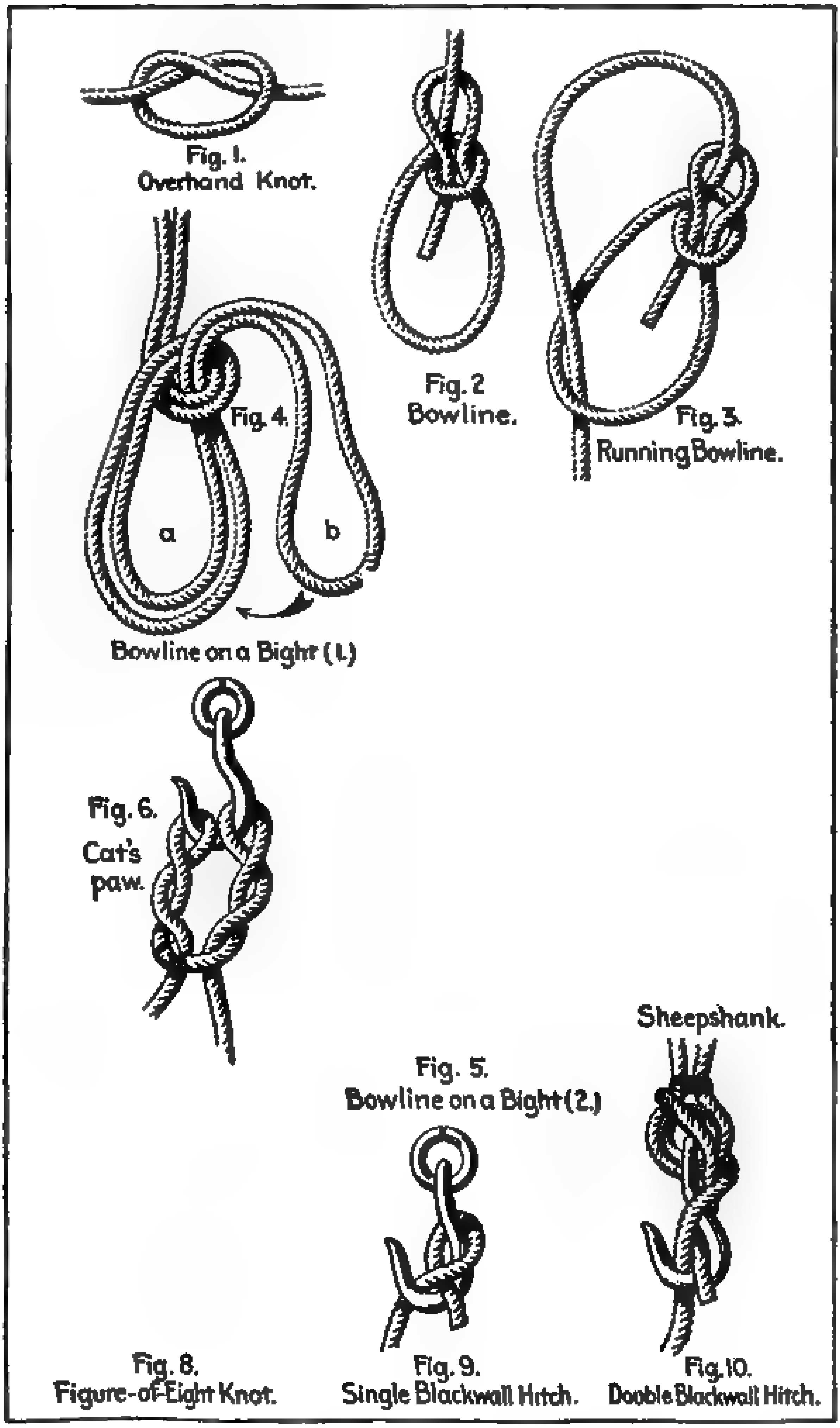
A **Bowline on a Bight.** Figs. 4 and 5. Used in place of a single bowline where greater strength is needed, or an increased number of parts.

A **Cats-paw.** Fig. 6. A double loop for hooking a tackle into the end of a rope. Convenient and secure.

A **Sheep-Shank.** Fig. 7. A quick and convenient way of temporarily shortening a rope.

A **Figure of Eight Knot.** Fig. 8. Turned in the end of a rope to prevent it from unreeving.

A **Blackwall Hitch.** Figs. 8 and 9. Used like the **cats-paw** for hooking a tackle to the end of a rope. The holding power of the Blackwall comes from the jamming of one part upon another. The single Blackwall cannot always be trusted.



KNOTS IN THE END OF A ROPE.

Plate 20. This plate shows a series of knots for joining the ends of the two ropes or the two ends of the same rope. This is perhaps the most important group of knots with which we have to deal.

A **Square-Knot or Reef-Knot.** Fig. 1. This is the simplest knot of the series and the most useful. But it cannot be used where the ropes to be joined are of different sizes unless the ends are stopped down to their own parts, as otherwise the ends will slip and draw apart.

A **Granny-Knot.** Fig. 2. Frequently confused with the **Square-Knot,** but is less neat and does not hold so well. Moreover it jams and is hard to untie. Is much despised by seamen.

A **Sheet or Becket Bend.** Fig. 3. Called by landsman a **Weaver's Knot** because used for knotting yarns. Is especially suited for use with small lines, like fish lines, but works well with ropes of any size. It can be used where the lines are of different sizes, and does not weaken the rope. Divides with the Square Knot the claim to be the most generally useful knot known.

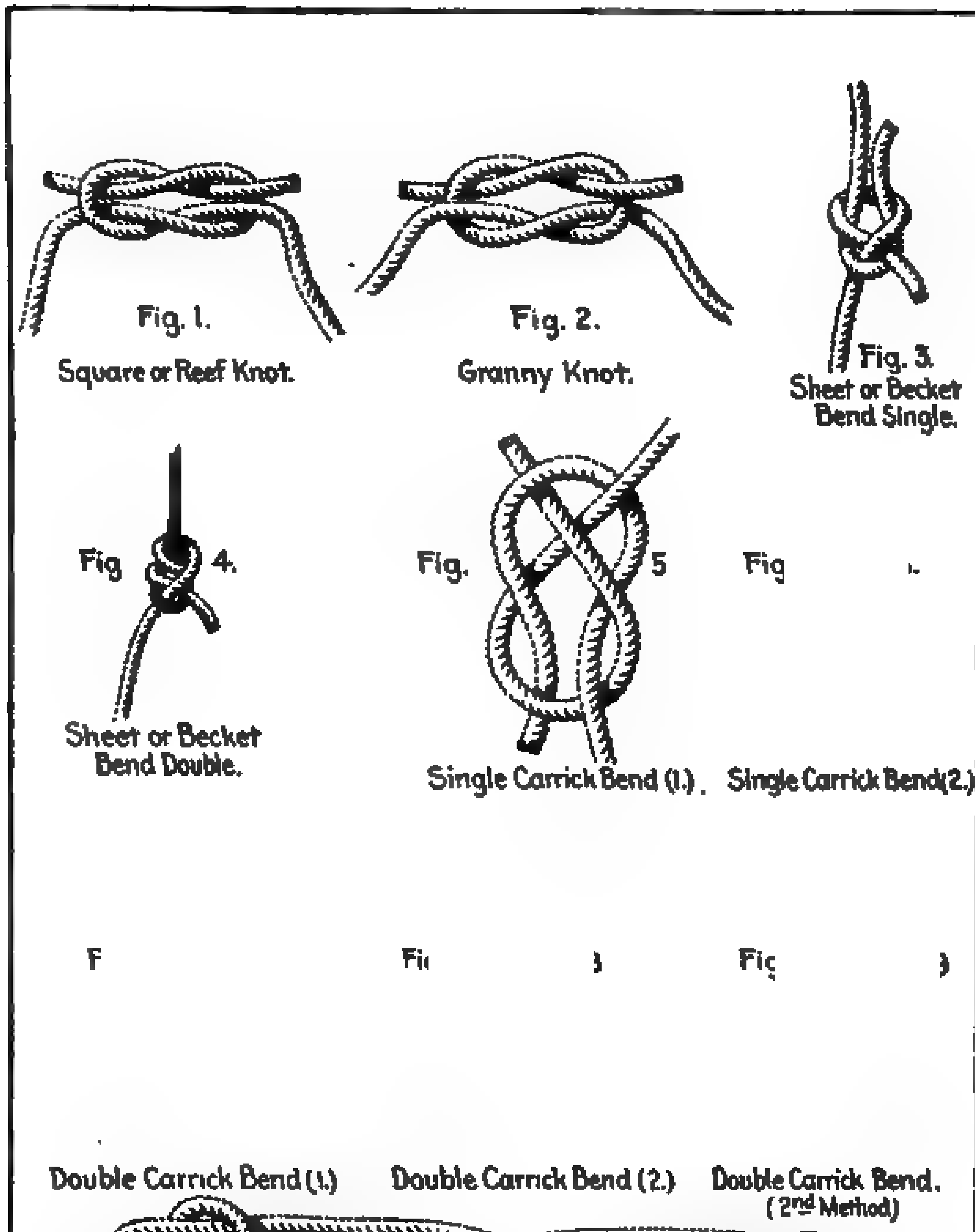
A **Sheet Bend, Double.** Fig. 4. Here the end of the bending line is passed twice around the standing line and twice through its own part, giving added security.

A **Single Carrick Bend.** Figs. 5 and 6. Compare with **Single Sheet Bend.**

A **Double Carrick Bend.** Figs. 7, 8 and 9. More secure than the Single Carrick, but with both it is well to stop down the ends to their own parts. This is especially necessary where the ropes are of different sizes.

Two Bowlines. Fig. 10. A safe and convenient way of bending two hawsers. Will not slip. Is somewhat bulky for use where the lines are to be veered out through a chock.

A **Reeving Line Bend.** Fig. 11. Neat and secure, but not as quickly made as the junction of two bowlines. Convenient for reeving through a chock.



BENDING TWO ROPES TOGETHER.

Plate 21. This plate shows various ways of securing lines to spars, posts, rings, etc.

A **Studding-Sail Tack Bend.** Fig. 1. A useful bend for a variety of purposes where it is important to have no danger of coming adrift through the flapping of a sail.

A **Studding-Sail Halliard Bend.** Fig. 2. The greater the pull on the halliards, the more tightly the parts of the bend are jammed against the spar. With regard to this and the preceding (Fig. 1), it is interesting to note that the "Stunsails" of a sailing-ship are peculiarly difficult to handle if anything goes wrong with their gear. For this reason it is especially important that all their gear should be so secured as to reduce to a minimum the danger of coming adrift.

A **Fisherman's Bend.** Fig. 3. May be made more secure by taking another turn with the end around the standing part before stopping down.

A **Timber Hitch.** Fig. 4. The greater the pull, the more tightly the turns are jammed.

A **Timber Hitch and Half Hitch.** Fig. 5. For towing a spar. The half hitch is taken first and the timber hitch afterward formed with the end.

A **Rolling Hitch.** Fig. 6. Very useful where one rope is to be bent to a spar or to the standing part (not the end) of another rope, or to a chain (as in Clearing Hawse).

A **Round Turn and Two Half Hitches.** Fig. 7. For making a hawser fast to a bollard. For greater security, the end should be stopped down to the main part. If the part A is taken up under B as well as under C, we have a Fisherman's bend, which, with a half hitch outside it as at D, is often used for this purpose. A more convenient way is to turn a bowline in the end of the hawser and throw it over the post.

Two Half Hitches. Fig. 9. Another way of bending a rope's end to a spar, a bollard, or a ring.

A **Clove Hitch.** One of the most common of hitches for attaching a rope to a spar or to the standing part of a rope. Used in hitching ratlines to shrouds.

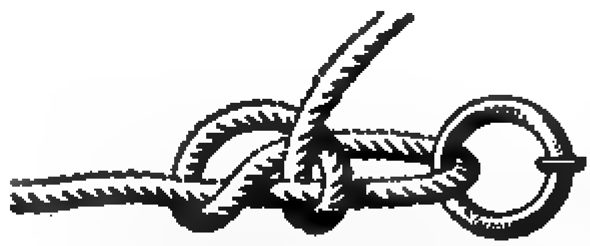


Fig. 1.
Studding Sail Tack Bend.

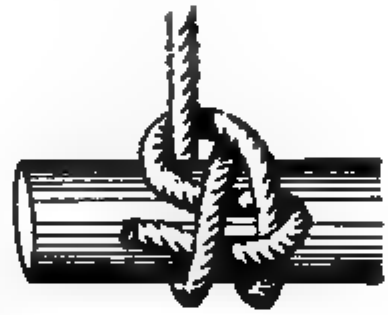


Fig. 2.
Studding-Sail
Halliard Bend.

Fig. 3.
Fisherman's Bend.

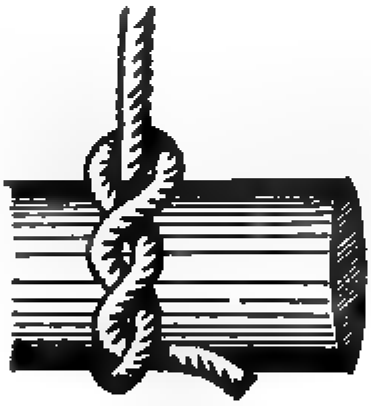


Fig. 4.
Timber Hitch.

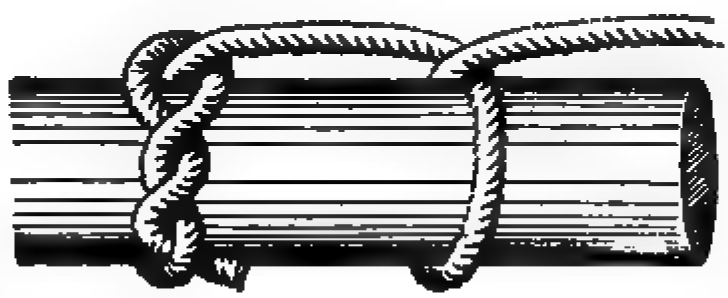
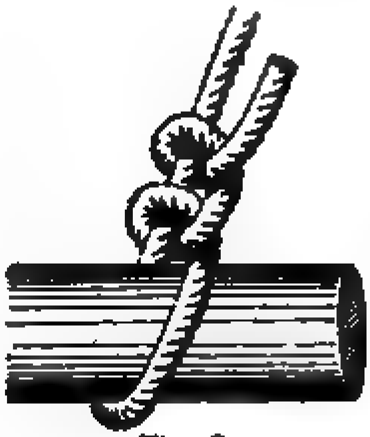


Fig. 5.
Timber and Half Hitch.

Round Turn and Two Half Hitches.



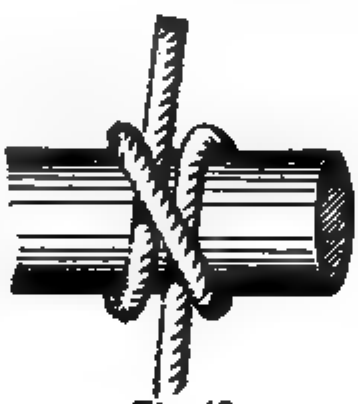


Fig. 8.
Rolling Hitch.

Fig. 9.
Two Half Hitches.

Fig. 10.
Clove Hitch.

BENDING A ROPE TO A POST, SPAR OR RING.

Plate 22. This Plate shows a series of knots which are worked in the end or the body of the rope by unlaying the rope and using its own strands. A whipping is usually put on below the point where the knot is to be. Knots of this kind are sometimes used to give a finish to the end of the rope, sometimes to prevent it from unreeving, and sometimes merely for ornamental purposes.

A **Wall-knot.** Fig. 1.

A **Wall and Crown.** Fig. 2.

A **Double Wall and Single Crown.** Fig. 3.

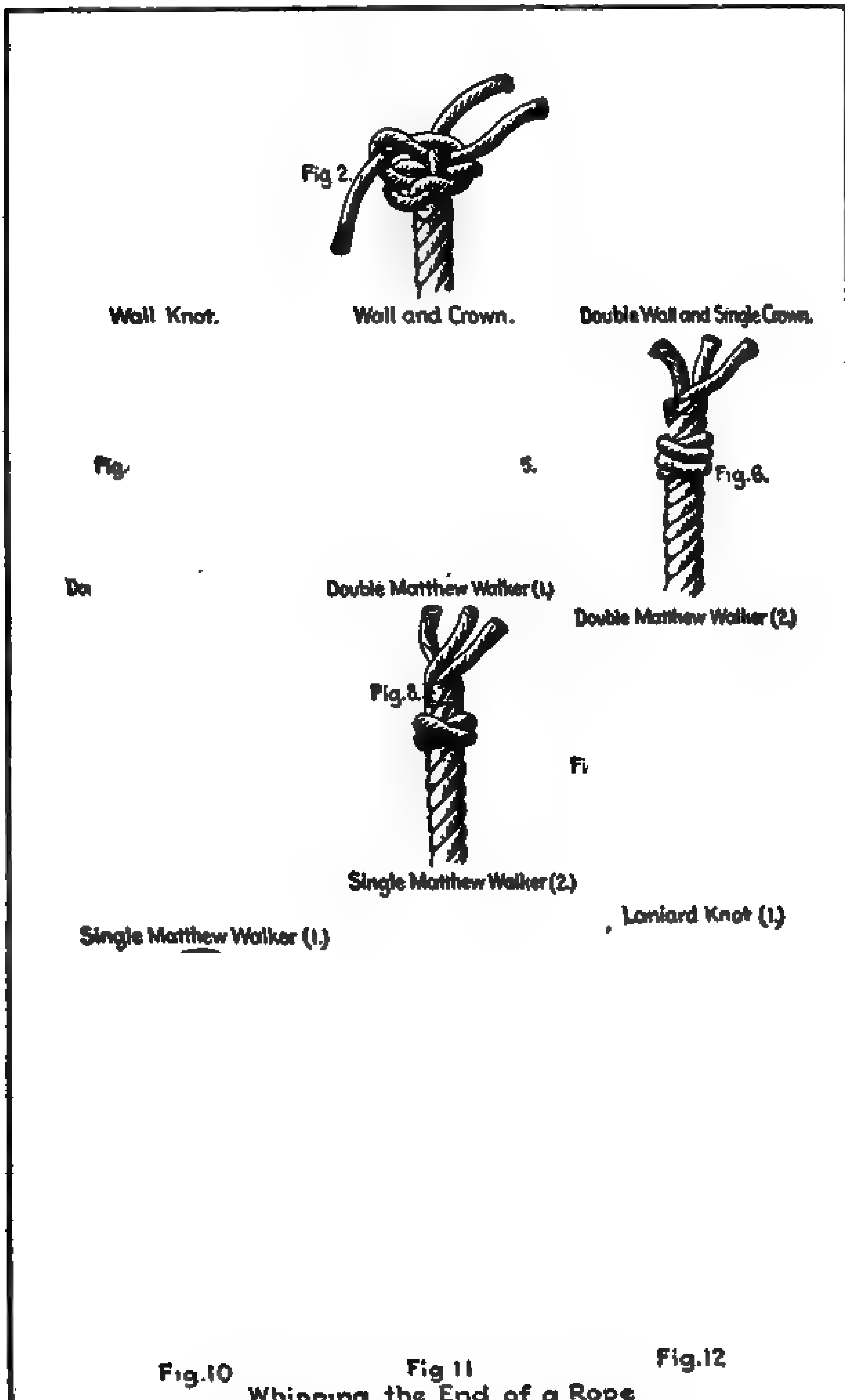
A **Double Wall and Double Crown** or **"Man-rope Knot."** Fig. 4. Used on the ends of "man-ropes" (trailing-lines over the sides) to give a good hold for a man overboard.

A **Matthew-Walker Knot,** double and single. Figs. 5 and 6, 7 and 8.

Whipping the end of a Rope (Figs. 10, 11, 12) to prevent unlaying or fraying out. Lay the end of a length of stout-twine along the rope and pass a number of turns around the rope and over the end of the whipping, hauling each turn taut. Fig. 9. Then lay the other end of the whipping along the rope in the opposite directions from the first end, and pass a number of turns, on the bight, over this end. Fig. 10. Haul the end through and trim off.

SPLICING.

There are various forms of splices for joining the ends of two ropes permanently, or for bending back the end of a rope upon itself to form a permanent eye. In making these, when the strands of a rope are to be tucked, the lay of the rope where they go through is opened out by means of a marline-spike, and the strand tucked through once in its full size, then reduced in size by cutting away a certain number of threads, tucked a second time, reduced once more in size and tucked again. It is thus tucked once full size, once two-thirds, and once one-third. This produces a tapered and much neater splice than if it were tucked three times in full size.



KNOTS WORKED IN THE END OF A ROPE.

Plate 23. This plate shows splices in Manila or Hemp, and Tools for Splicing.

An **Eye-Splice.** Figs. 2, 3 and 4. The rope is unlaid for perhaps a foot from the end, and the strands brought back upon the body of the rope at a point which will form an eye of the size that is wanted. Beginning with any one strand, this is tucked from left to right, through the strands of the rope (which are opened by a spike), being passed over one and under the next. The other two strands are similarly tucked, always from right to left. All three are then trimmed down to two-thirds their original size, tucked again, trimmed to one-third size and tucked a third and last time.

An **Eye-Splice in four-stranded rope.** Here the first strand is tucked under two; but this for the first tucking only.

A **Short Splice.** Figs. 5, 6 and 7. Two ropes are unlaid for a short distance and married together with strands interlacing (Fig. 5). The strands of each rope are then tucked through the lay of the other rope exactly as has been described in the case of an eye-splice.

A **Long Splice.** Figs. 8 and 9. Here the ropes are unlaid for a greater distance than for a short splice and the ends brought together as before, with strands interlacing. Instead now of tucking at once, we proceed as follows: Unlay a_1 one of the strands of A, for a considerable distance, and in place of it lay up b_1 the adjoining strand of B, thus working a strand of B into A, for, say, a foot and a half or two feet. For convenience now twist up a_1 and b_1 together temporarily, as in Fig. 9. Turn the rope end for end, unlay b_2 one of the strands of B, and in place of it lay up a_2 the adjoining strand of A. a_3 and b_3 are left lying beside each other without being unlaid. We now have three pairs of strands at different points of the rope. Beginning with a_2 and b_2 (for example) separate each of these strands into two parts, and taking one-half of each strand, overhand knot these together (*K*, Fig. 9) and tuck them as in a short splice, over one and under one of the full remaining strands in the rope. (*M*, Fig. 9.)

The other pairs of strands (a_1 b_1) (a_2 b_2) are similarly reduced, knotted, and tucked. The spare half of each strand is trimmed off smooth, as are the ends of the other halves after they have been tucked.

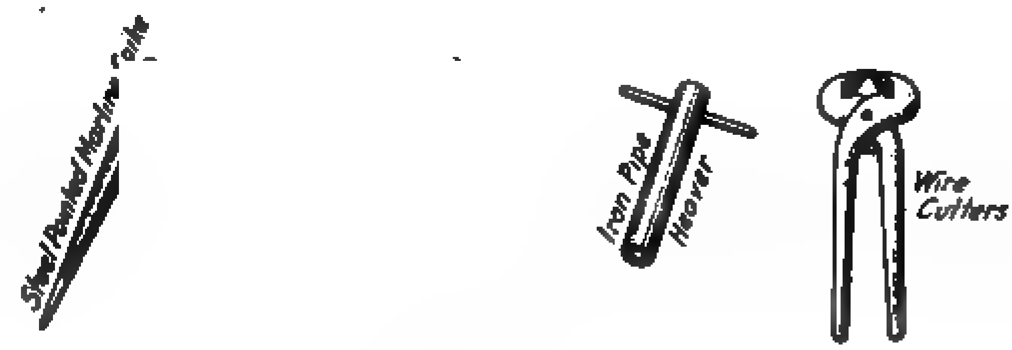


FIG. 1.
TOOLS FOR SPLICING

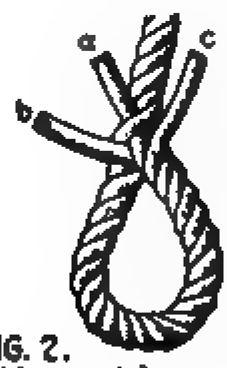


FIG. 2.
EYE SPLICE (1)

FIG. 3. EYE SPLICE (2)

. IG. 4.
EYE SPLICE (3)

FIG. 5.
SHORT SPLICE (1)

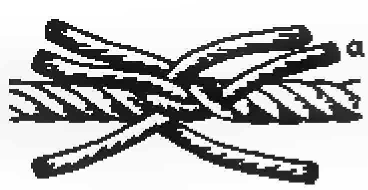


FIG. 6.
SHORT SPLICE (2)

FIG. 7.
SHORT SPLICE (3)

FIG. 8. LONG SPLICE (1)

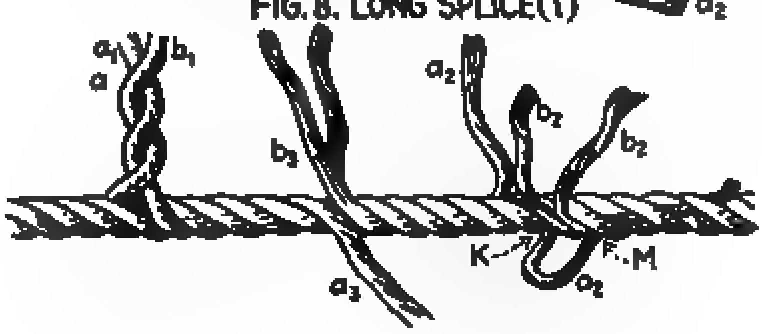


FIG. 9. LONG SPLICE (2)

SPLICES, HEMP AND MANILA.

WORKING IN WIRE-ROPE.

As already stated, wire-rope is usually six-stranded, with a hemp heart. In splicing, we may work with the strands separately or in pairs. The work calls for special appliances and for a degree of skill such as can be acquired only by long practice under expert instruction. Something may be learned from careful description, and much more from an occasional visit to a rigging loft; but the facilities which are available on ship-board do not admit of doing such work as is possible with a rigger's bench, a turning-in machine, etc. Where a heavy rope is to be bent around a thimble or the parts otherwise brought together for splicing or seizing, a rigger's-screw is needed. In the absence of this, a vise may be used, but less conveniently.

In tucking the strands of a splice, the lay of the rope is opened out and *the spike left in,* holding the strands apart, until the tuck has been made. For dragging the strands through, a jigger is used on each one, the body of the rope being held by another jigger or a lashing. After a tuck, the parts of the ropes are hammered down tightly upon each other. Wire-cutters are used for cutting off ends.

PLATE 24. **A Long Splice in Wire.** Figs. 1 and 2. Put on a good seizing six to ten feet—according to the size of the rope—from the end of one of the ropes to be spliced, and a similar seizing one to two feet from the end of the other rope. Unlay, open out the strands, cut out the heart, and marry the ends together with strands interlacing. Cut the seizing on the short end. Unlay one of the short strands, following it up in the same lay with the opposite long strand, leaving end enough to tuck. Continue in the same manner with the remaining strands, except as to the distance to which they are laid up, this distance being varied in such a way as to leave the successive pairs an equal distance apart, as shown in Fig. 2. Commencing with any two strands, half knot them together (full size), then divide each into three parts, and tuck these parts separately as shown;—or, cut out a few inches of the heart and insert the ends of the strands in its place in the centre of the rope. When a splice is to be served, the latter way of finishing it off answers very well.

Second Method (Figs. 3 and 4). Will be clear from Plate.

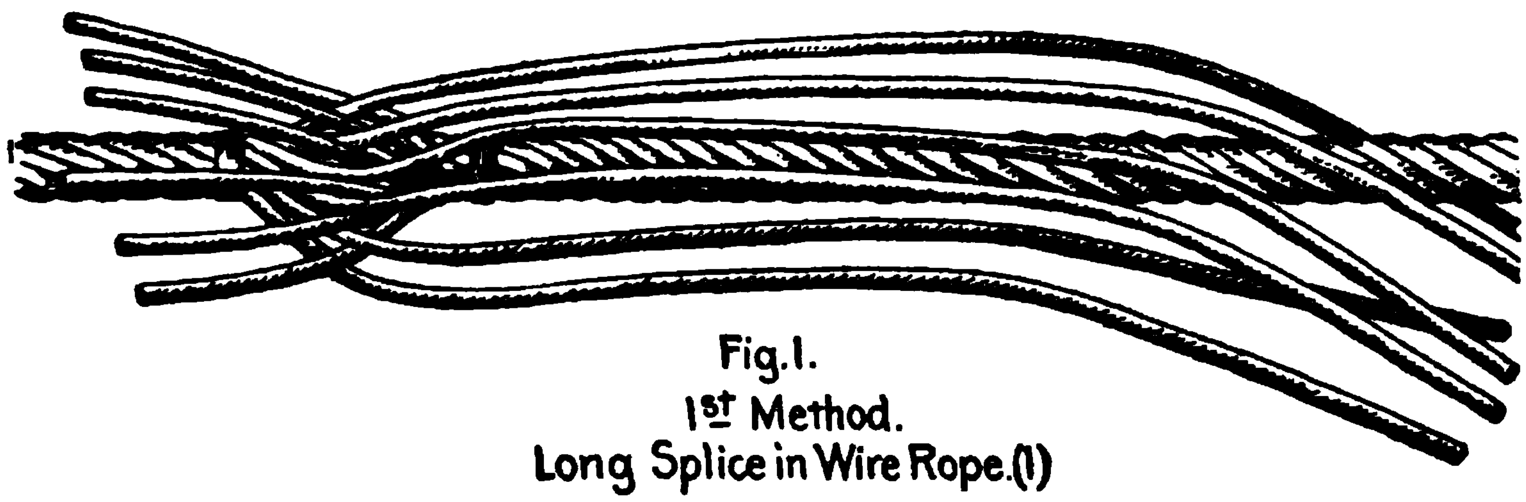


Fig. 1.
1st Method.
Long Splice in Wire Rope. (1)

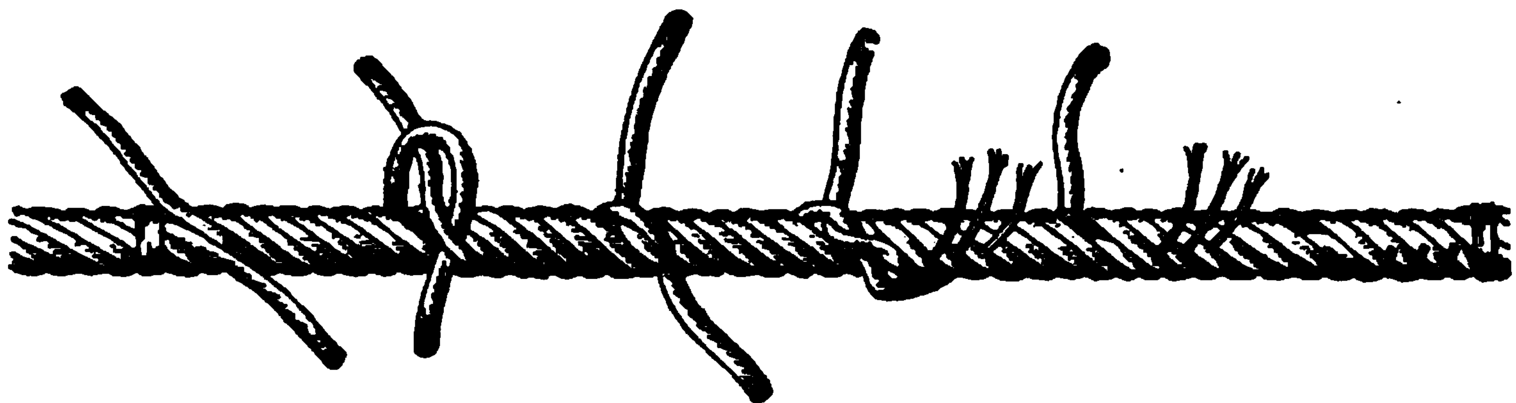


Fig. 2.
1st Method.
Long Splice in Wire Rope. (2)

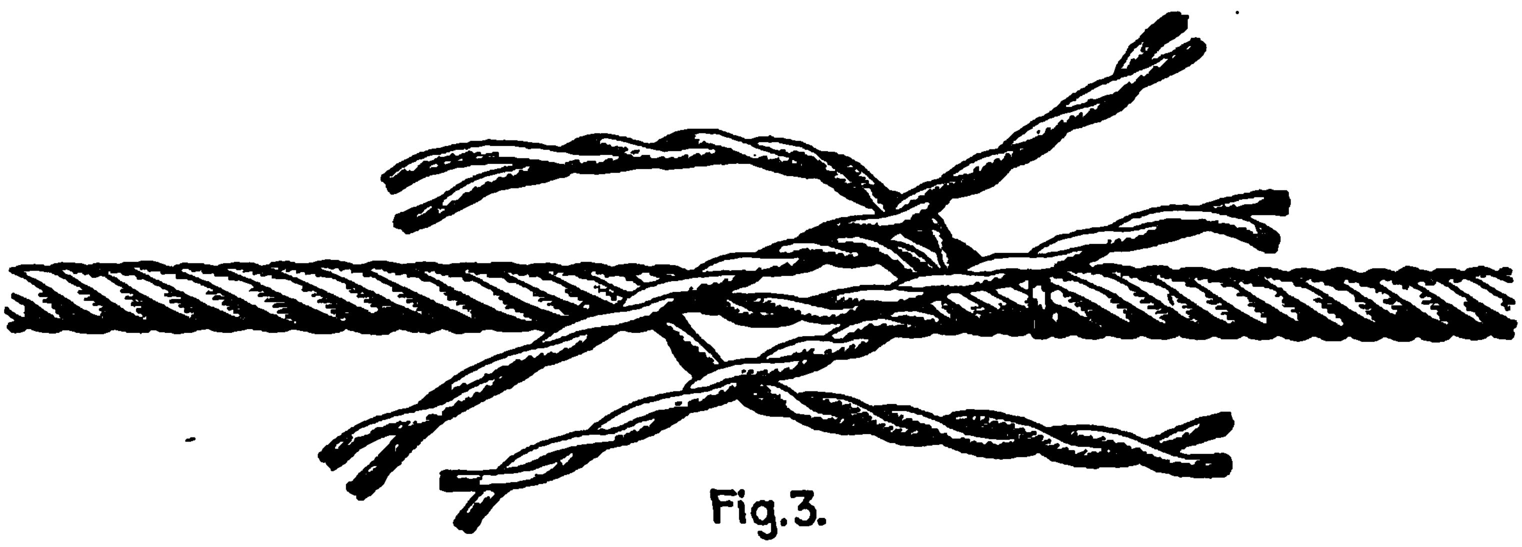


Fig. 3.
2d Method.
Long Splice in Wire.

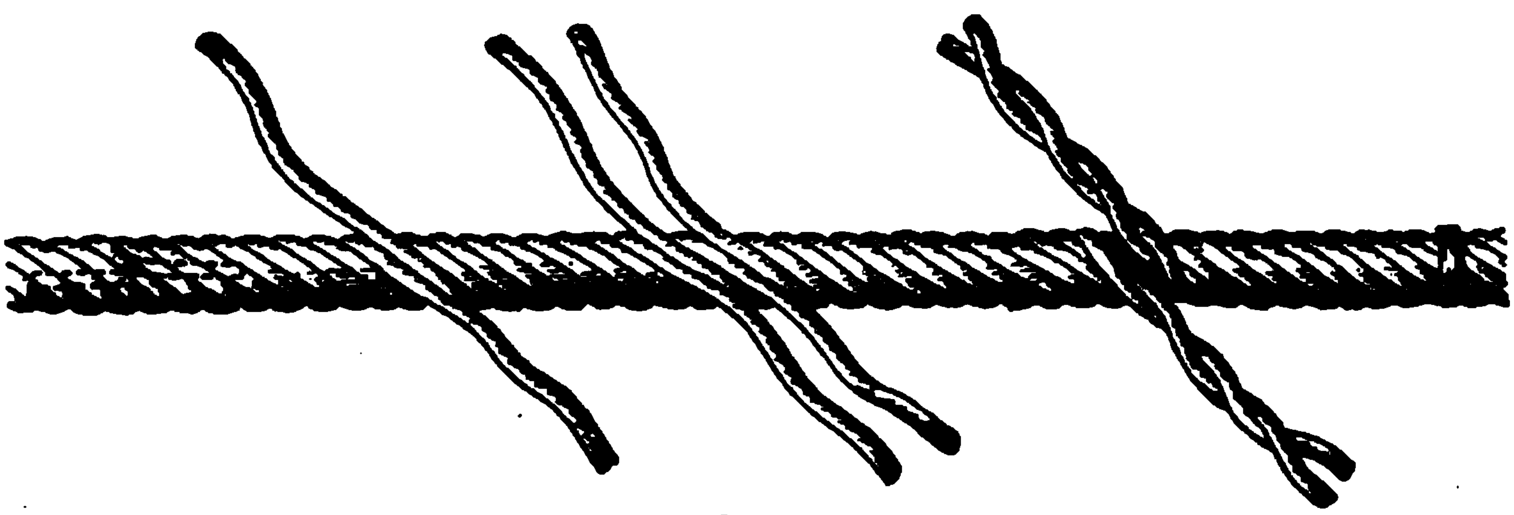


Fig. 4.
2d Method.
Long Splice in Wire.

LONG SPLICE IN WIRE.

PLATE 25. **A Short Splice in Wire.** Fig. 1. Put on a good seizing two or three feet—according to the size of the rope—from the end of one of the ropes to be spliced, and a similar seizing one or two feet from the end of the other rope. Unlay the ends and open out the strands, cutting out the heart close to the seizings. Marry them together and clap on a temporary seizing around the short ends and the body of the rope, to hold the parts close together. Commencing with any one of the long strands, tuck each in succession over one and under two strands, opening out the lay with a spike. Tuck the remaining strands in the same manner;—twice whole strands, once one-half, and once one-quarter, hauling through with a jigger each time. Then turn the splice around, cutting the temporary seizing on the short ends, and tuck the short strands once one-half and once one-quarter, heaving them through with a jigger. Hammer down all parts and trim off the ends.

An Eye-splice in Wire. Fig. 2. Get the rope on a stretch, allow from 18 to 24 inches from the end for splicing, and put on a mark with a couple of turns of twine. Measure along the rope from this mark the length of the eye (once and one-half the round of the thimble) and put on another similar mark. Paint with red lead, worm, parcel, paint again, and double-serve between the marks. Now come up the stretch and seize the thimble in, breaking the rope around by the rigger's-screw and putting on a good racking seizing around both parts. Come up the screw, unlay the end of the wire, and cut out the heart close to the service. Now, with the thimble toward you, counting from right to left 1, 2, 3, etc., stick No. 4 strand from right to left under the upper strands of the rope just clear of the service, opening the strands by a spike. Haul through by hand. In the same manner—under two and over one strand—tuck the remaining strands, in the following order: 3, 5, 2, 6, 1. Now, commencing with any strand, tuck again whole and haul through by means of a jigger. Hammer the strands down in place, cut each strand down to one-half size and tuck again, hauling through with a jigger as before. Cut the strands down to one-quarter and tuck again. Hammer down all strands and cut off the wire with a wire-cutter.

Fig. 1
A Short Splice in Wire

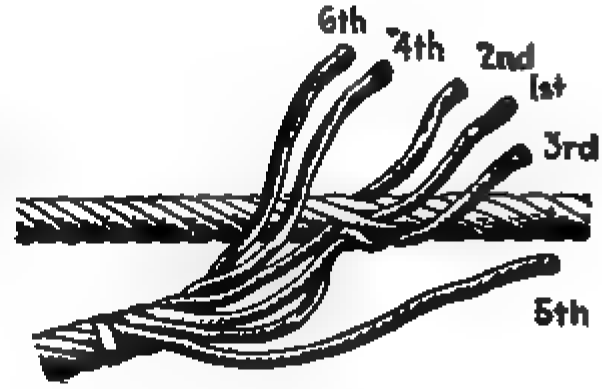


Fig. 2
An Eye-Splice in Wire

Fig. 3
Round Seizing

Fig. 4
Round Seizing

Fig. 5
Round Seizing Crossed
Clove Hitch Finish

Fig. 6
Racking Seizing

Fig. 7
Racking Seizing

Fig. 8
Throat Seizing

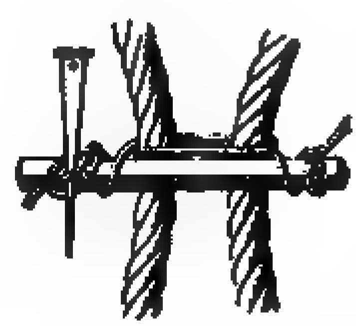


Fig. 9 Spanish Windlass

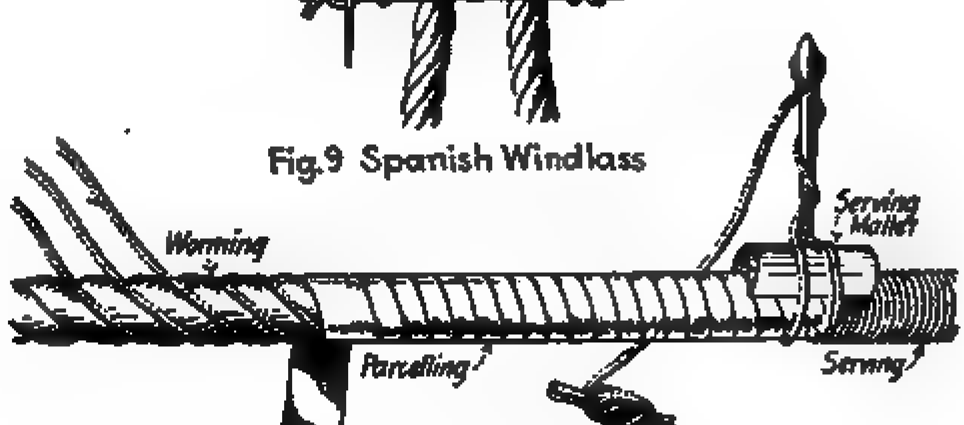


Fig. 10 Worming, Parcelling and Serving

SPLICES—SEIZINGS.

Figs. 3, 4, 5, 6, 7, 8. Seizings for binding together two ropes or two parts of the same rope. The manner of passing them is made clear by the figures. With heavy ropes, the parts must be hove together by power of some kind, such as a Spanish Windlass, a rigger's-screw, or a turning-in machine.

Worming, Parcelling, and Serving. Fig. 10. Rope which is to be exposed to the weather or to exceptionally hard usage is protected by worming, parcelling, and serving.

Worming consists in following the "lay" of the rope, between the strands, with small-stuff, tarred, which keeps moisture from penetrating to the interior of the rope, and at the same time fills out the round of the rope, giving a smooth surface for the parcelling and serving.

Parcelling consists in wrapping the rope spirally with long strips of canvas, following the lay of the rope, and overlapping like the shingles on a roof to shed moisture.

Serving consists in wrapping small-stuff snugly over the parcelling, each turn being hove taut as possible so that the whole forms a stiff protecting cover for the rope. A "serving-mallet" is used for passing the turns, each turn being hove taut by the leverage of the handle as illustrated in Plate **25,** fig. 9.

Fig. 9. **A Spanish Windlass,** for drawing two taut ropes together.

PLATE **26. Appliances for use with Wire Rope.** Most of the appliances for use with wire rope are designed to provide some sort of an eye on the end of the rope, by which it can be connected with another rope or with a tackle, or otherwise secured. Plate **26** illustrates a number of these. It will be seen that any two of the ends shown can be joined together, either directly or by the aid of a shackle. Fig. 2 shows a handy *clip* and the manner of applying it. These clips, when made of drop-forged steel and properly applied, are little if at all inferior to a splice. And they can be applied in a few moments where a splice would take as many hours. In the emergencies which sometimes arise on shipboard, as in handling anchors, taking a vessel in tow, etc., when an eye is needed in a hawser and there is not time to make a splice, these clips would be invaluable. They can be removed as quickly as they are applied, breaking down the eye at once.

A set of these in sizes to fit any hawser on board might well

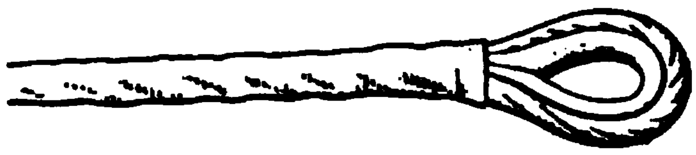


FIG. 1
THIMBLE EYE, SPLICED AND SERVED

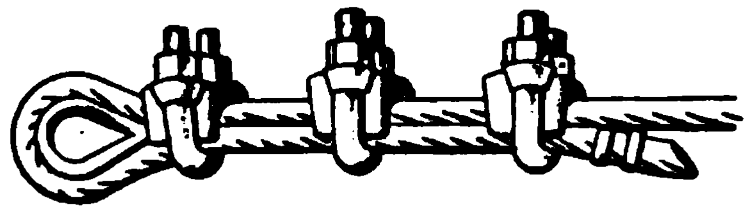


FIG. 2
THIMBLE EYE WITH WIRE ROPE CLIPS

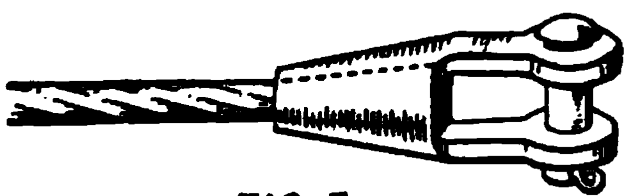


FIG. 3
OPEN END SOCKET

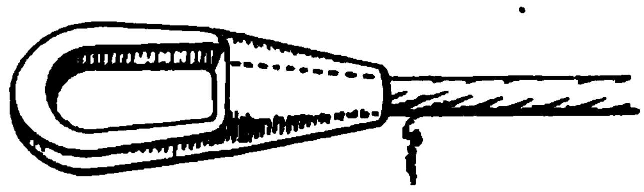


FIG. 4
CLOSED END SOCKET

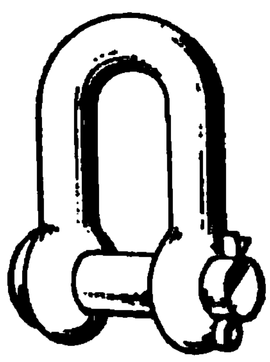


FIG. 5
SHACKLE

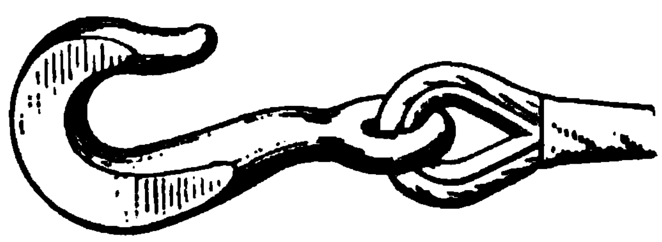


FIG. 6
HOOK AND THIMBLE

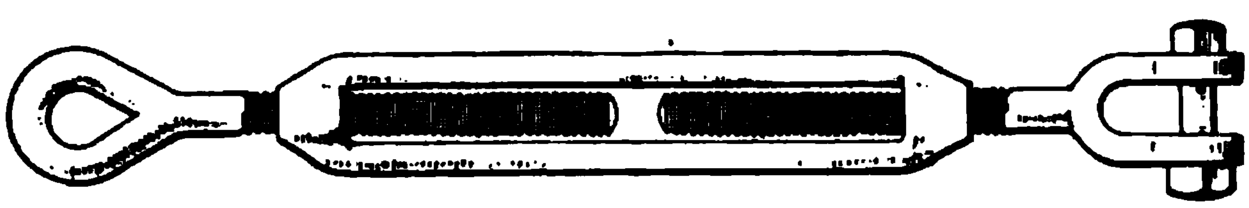


FIG. 7
TURNBUCKLE

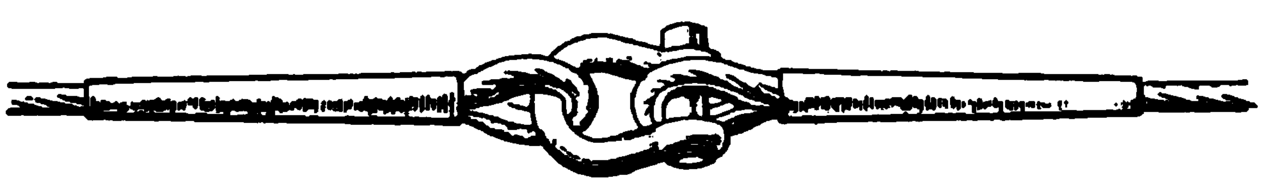


FIG. 8
JOINING THE ENDS OF ROPE

APPLIANCES FOR USE WITH WIRE ROPE.

be issued to all ships. Note that the U-bolt is always applied to the "dead" end of the rope.

The *socket* shown in Figs. 3 and 4 is the strongest attachment known for use on the end of a wire rope. The interior of the base of the socket is coned and the bare end of the rope is bedded in and sealed with molten zinc, which forms a head that holds without distortion of the wires.

CHAPTER V.

MECHANICAL APPLIANCES ON SHIP-BOARD.

The successful use of mechanical appliances on ship-board calls for a familiarity with certain elementary principles of mechanics which may thus be properly regarded as a part of Seamanship.

From this point of view they will be treated here as preliminary to the handling of heavy weights.

The popular conception of forces and of the manner of measuring them may be accepted as sufficiently exact for our present purpose.

The Composition and Resolution of Forces.

For every force acting upon a body there is a certain "line of action" along which it tends to move this body. If several forces act upon the same body at the same time, the total effect produced will be, both in magnitude and in direction, a combination of the effects of the individual forces; and it is found that we may substitute for any such combination of forces, a single force of definite magnitude and direction; and that the magnitude and direction of this "resultant force" as it is called, may be deduced from the original forces by a very simple construction.

The derivation of a single resultant from several distinct forces is called "The Composition of Forces."

It is found also that we may reverse the above process, and, from a single given force, find two or more forces acting along given lines which may be substituted for the one original force without any change in the effect produced. This process is called "The Resolution of Forces"; and the forces resulting from it are "components" of the original force from which they are derived. In discussing these principles and applying them to practical problems, we may conveniently denote a force by a *line* of a certain length, the number of units of length taken

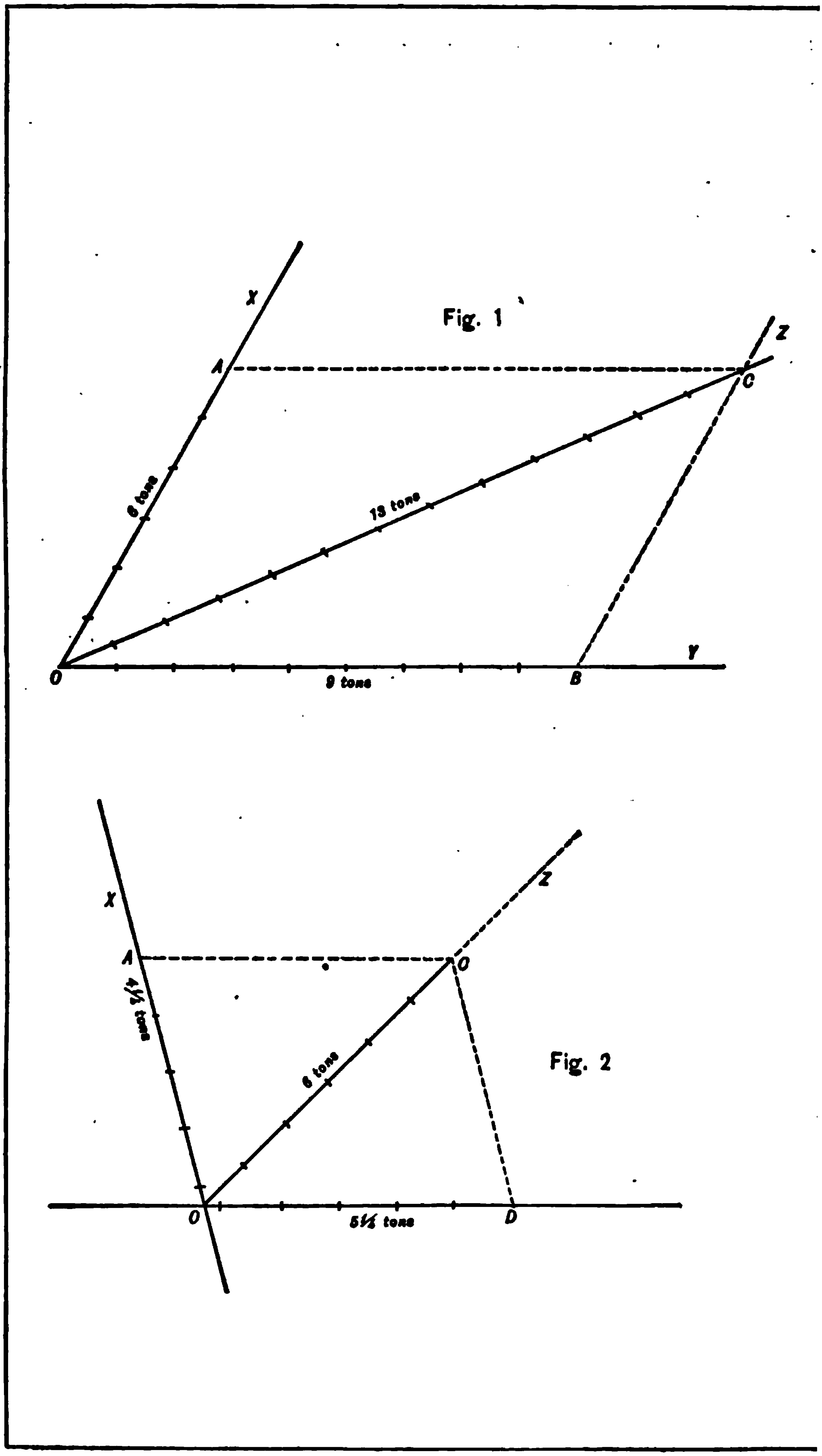
being equal to the number of units of force to be represented. Thus a force of 5 tons may be denoted by a line five units in length;—the units being feet, inches, tenths of inches, or anything else that we like to use. The scale is merely a matter of convenience, but the same scale must of course be used in all parts of the same problem.

We proceed to illustrate the Resolution and Composition of Forces.

In Fig. 1, Plate 27, suppose O A and O B to represent two forces acting along the lines O X and O Y, and suppose it is desired to find a single force which may replace these without change in effect upon O. We construct the parallelogram A O B C and draw the diagonal O C. This diagonal represents, in direction and in length, the desired resultant; its length being measured, of course, in the same units that have been used in laying off O A and O B. In this case, if O A = 6 tons and O B = 9 tons, O C, the resultant = 13 tons. That is to say, a force of 13 tons acting along O Z, will produce exactly the same effect as six tons acting along O X and nine tons acting along O Y. If we have to deal with three or more original forces, we may couple two of them and find a resultant, then couple this resultant with another one of the original forces and proceed as before to find the resultant of these, and so on.

It is clear that, by reversing the above process, we may resolve a single given force into two or more others acting along certain lines. Having given 13 tons acting along O Z, suppose we are called upon to find two forces which, acting along O X and O Y, shall be equivalent to this original force. As before, we construct the parallelogram A O B C. Then the sides O A and O B represent by their lengths the forces which, acting in these two directions, are equivalent to O C. O A is found to be 6 tons and O B, 9 tons. Similarly in Fig. 2, suppose we have a force denoted by the length of O C acting along O Z, and wish to resolve this along the lines O X and O Y, making angles of 45° and 60° with O Z. Constructing the parallelogram O B C A as before, we have the lengths O A = 4¼ tons, and O B = 5¼ tons, for the forces required.

Evidently, if a point is at rest, the forces acting upon it must balance each other. Consider the case illustrated in Fig. 1, Plate 28, of a weight suspended from a boom, the heel of which



THE COMPOSITION AND RESOLUTION OF FORCES.

is attached to the mast while the other end is supported by a topping-lift from the masthead. The forces acting here are the downward pull of the weight, the tension on the lift, and the resistance of the boom to compression (Fig. 2, Plate 28). As the point O remains at rest, these forces must balance each other;—that is to say, each force considered by itself must be balanced in magnitude and direction by the resultant of the other two forces. If this were not so, motion would result. Suppose we wish to find the tension on the topping-lift. We lay off O C on any convenient scale to represent the downward pull of the weight, and on O C as a diagonal, construct the parallelogram O B C A (Fig. 1, a). O A is the measure of the tension on the topping-lift, and O B that of the thrust along the boom. If the weight is 9 tons, O A is 6¾ tons and O B is 4½ tons.

There follows from the above a simple and convenient rule for determining the relative stresses on the various parts of the system from a simple comparison of their relative lengths. The sides of the triangle O A C are parallel to the sides of the triangle formed by the mast, the boom, and the topping-lift.

These two are therefore "similar" triangles in the geometrical sense of the term, and it follows that the same relations exist between the sides of one of them as between the corresponding sides of the other; that is to say, the side O A, which represents the tension on the topping-lift, is the same proportion of O C, the downward pull of W, that the length of the topping-lift is of the length of the mast. From which we have the convenient rule expressed by the following proportion.

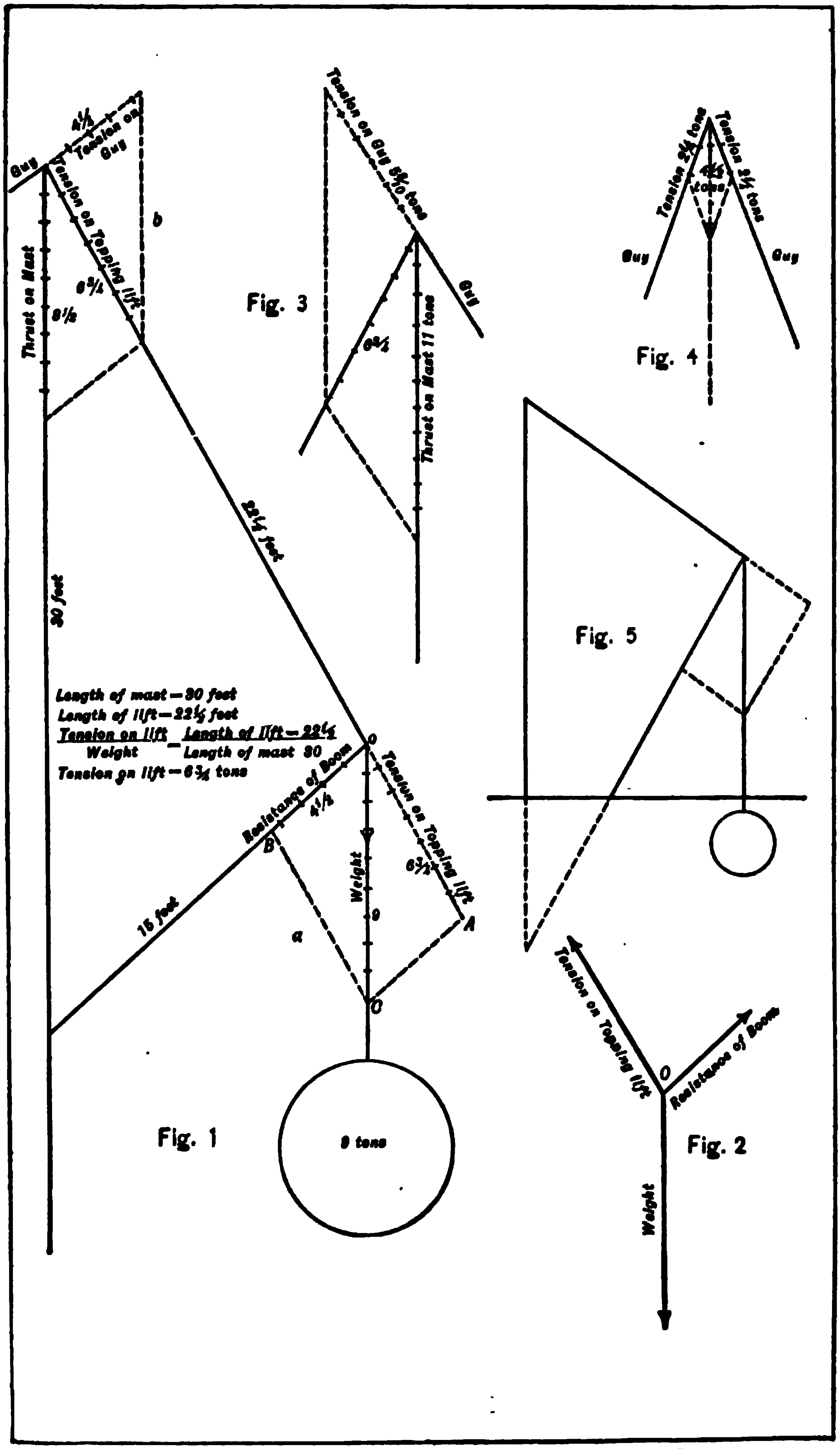
$$\frac{\text{Tension on Topping-lift}}{\text{Weight}} = \frac{\text{Length of Topping-lift}}{\text{Length of Mast}}.$$

If the boom is stepped at a distance from the mast, this rule may be applied by prolonging the line of the boom until it intersects the mast, and using in calculation, the lengths given by this construction (Fig. 5, Plate 28).

Similarly we may deduce the rule:

$$\frac{\text{Thrust on boom}}{\text{Weight}} = \frac{\text{Length of boom}}{\text{Length of mast}}$$

It will be understood that the lengths given above for mast and boom are those actually included in the triangles of Figs. 1 and 5.



THE COMPOSITION AND RESOLUTION OF FORCES APPLIED TO A DERRICK.

This leads to a further important deduction with regard to the most favorable relation between the mast, the boom, and the topping-lift, as follows:

For a fixed length of mast and boom, we cannot change the thrust on the boom by any change in its angle; but we may vary the tension on the topping-lift within wide limits. Since this tension depends upon the length of the topping-lift, it grows less and less as the boom is topped up, becoming a minimum when the boom is as nearly vertical as it can be made. It is, at this point, very much less than the tension on o w due to the direct downward pull of the weight; but if we lower the boom toward the horizontal we presently reach an angle, depending upon the length of the boom, at which the length of the lift is equal to the length of the mast. At this point, then, the tension on the lift is equal to that along o w. If we lower still further, the tension on the lift increases beyond that on o w and may become very much in excess of it. For a given length of mast and boom, then, the more nearly vertical the boom can be used the better. If we are at liberty to vary the length of the mast and boom to attain *a given reach,* we shall find that a short boom, nearly level, gives a minimum strain on the boom and a maximum strain on the lift; while a long boom, well topped-up, gives a maximum strain on the boom and a minimum strain on the lift.

Suppose the boom is half as long as the mast. The thrust on it will be one-half the weight, no matter what the angle of the boom may be. The tension on the topping-lift will be about 1¼ times the weight when the boom is level, and rather less than ¾ of the weight when the boom is topped up to 45°.

The practical conclusion from this is that if we are called upon to rig a derrick we should consider carefully the relative trustworthiness of the materials with which we have to work. If we have a topping-lift which is abundantly strong, to be used with a boom about which we are not so sure, it is well to make the boom as short as possible and keep it nearly level. If on the other hand the boom and its fastenings are known to be safe but the topping-lift is not entirely satisfactory, we should use the full length of the boom (or choose a longer one if we have a choice) and top it up as far as possible, to give the required reach. If the reach is such that a *long boom must be used and*

kept nearly level, we have the maximum of unfavorable conditions as regards both boom and lift. In this case all that we can do is to lead the lift from a point as far up the mast as is practicable. This increases the absolute length of the lift, but decreases its relative length as compared with the mast; and, as we have seen, it is the relative and not the absolute length that determines the proportion of strain to be borne by the lift.

This case—of a long boom nearly level—is the ordinary one of a lower yard used for handling weights.

If the weight is suspended from the boom (or yard) outside or inside of the point at which the lift or burton is made fast, the situation is somewhat modified, as will be explained in connection with the Lever.

If we wish to find the tension on the guys or shrouds supporting the mast, we start with the tension on the lift, and resolve this along the lines of the guy and the mast, exactly as we have already resolved the downward pull of the weight along the line of the boom and the lift. In Fig. 1, b, Plate **25**, the tension on the guys is found by this method. In the particular case there illustrated it proves to be 4¼ tons. If we vary the lead of the guy, we shall find that, by bringing it closer to the mast, as in Fig. 3, we increase the tension on it, exactly as we do in the case of the topping-lift when we bring this down the mast and make it fast only a little distance above the heel of the boom.

If there are two guys (or shrouds) in use, we have only to resolve the tension above found for a single guy along the lines of the two which replace it, as in Fig. 4. In this particular case, assuming the angle between the guys to be 40°, we find the tension on each to be 2¼ tons.

There is an important difference between the case in which the derrick is used with a fixed elevation and that in which it is to be topped up or lowered with the weight hanging from it. In the first case, the only demand upon the parts of the topping-lift is that arising from the downward pull of the weight, this pull being resolved along the line of the topping-lift as above described. In the second case, there is added to this an important percentage due to the resistance of friction, as is explained in the Chapter on Tackles.

(See Practical Examples at the end of Chapters VI and VII.)

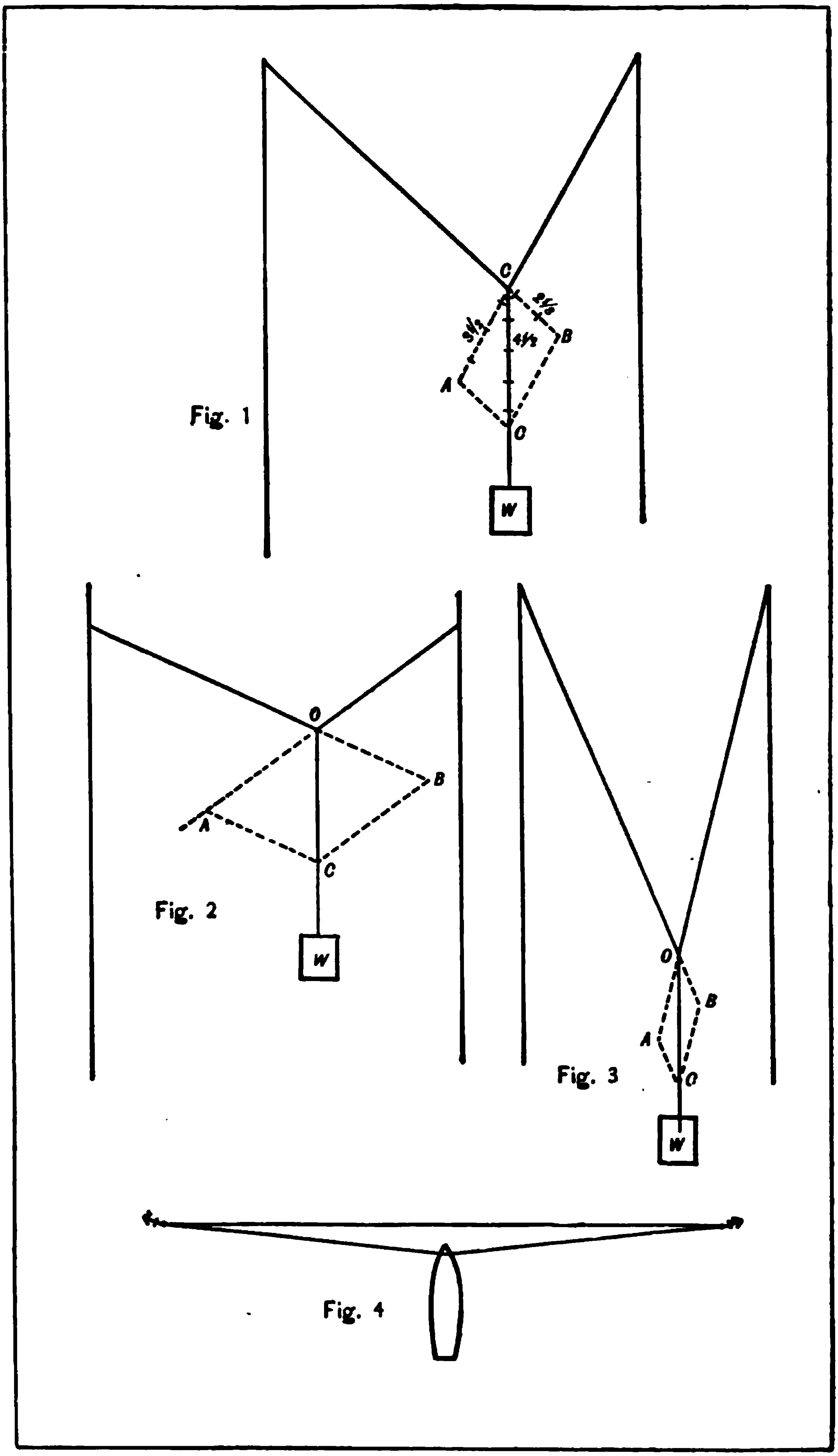
THE SPAN.

As another practical example of the resolution and composition of forces, we may consider the Span (Plate 29).

Suppose first that this is rigged between two masts for plumbing a hatch. If the two parts of the span make equal angles with the vertical, they will bear equal strains; otherwise the one which hangs more nearly vertical takes the greater strain. In Fig. 1, if the length O C represents the number of units of force in the downward pull of W, we find the tension on the two parts of the span by constructing the parallelogram of forces as in the cases already considered; O A giving the tension on one part and O B that on the other. It will be noted that if the parts of the span are opened out, increasing the angle A O B, as in Fig. 2, the parallelogram is flattened out, with a rapid increase in the length of the sides which represent tensions on the parts; whereas if they are brought together, as in Fig. 3, the tensions indicated on the parts are reduced. When the angle of the span is 120°, the tension each part is equal to the direct downward pull of the weight; or, in other words, the span is just equal in strength to the single part O W. If the angle is reduced below 120°, the tension on each part decreases, until, when they are parallel, they divide between them the total tension due to the weight;—in other words, the two parts are now twice as strong as the single part O W. On the other hand, as the parts open out beyond 120°, the essential weakness of the span becomes more and more apparent, the tension on the parts increasing enormously as the angle between them approaches 180°.

It is evident from the above that the use of a span is objectionable unless the angle between the parts can be made small; and that in any case where it is to be used, the higher up the masts the parts can be made fast, the better.

A familiar example of a span is furnished by the cables of a vessel moored and riding with an open hawse. If in Fig. 4, Plate 29, the parts of the span represent the cables of such a vessel, making an angle of 170° with each other, it can be shown that for a force of 10 tons acting along the keel line, we have a tension of 57.3 tons on each cable. In other words, two cables used in this way are only about one-sixth part as strong as one cable laid out ahead. (See Chapter on Ground Tackle.)



THE COMPOSITION AND RESOLUTION OF FORCES.
APPLIED TO A SPAN.

The Lever.

Another important principle of Mechanics which is involved in work on ship-board is that of the Lever.

A lever is a rigid bar movable about a fixed point called the "fulcrum."

It is a matter of every-day experience that two equal forces applied at equal distances from the fulcrum of a lever will balance; and that a small force applied at a considerable distance on one side will balance a greater force applied at a shorter distance on the other side. We have here illustrated, the principle of the lever; or, as it is sometimes called, the Principle of Moments; a "moment," in the mechanical sense, being the product of a force acting on a lever multiplied by the length of the arm with which it acts.

The Principle of Moments is expressed in the following statements.

1st. The tendency of a force to produce motion about an axis is measured not by the magnitude of the force alone, but by the product of the force into the distance of its line of action from the axis.

2d. If any system remains at rest, the sum of the moments tending to turn it in any direction about any axis must be equal to the sum of the moments tending to turn it in the opposite direction about the same axis.

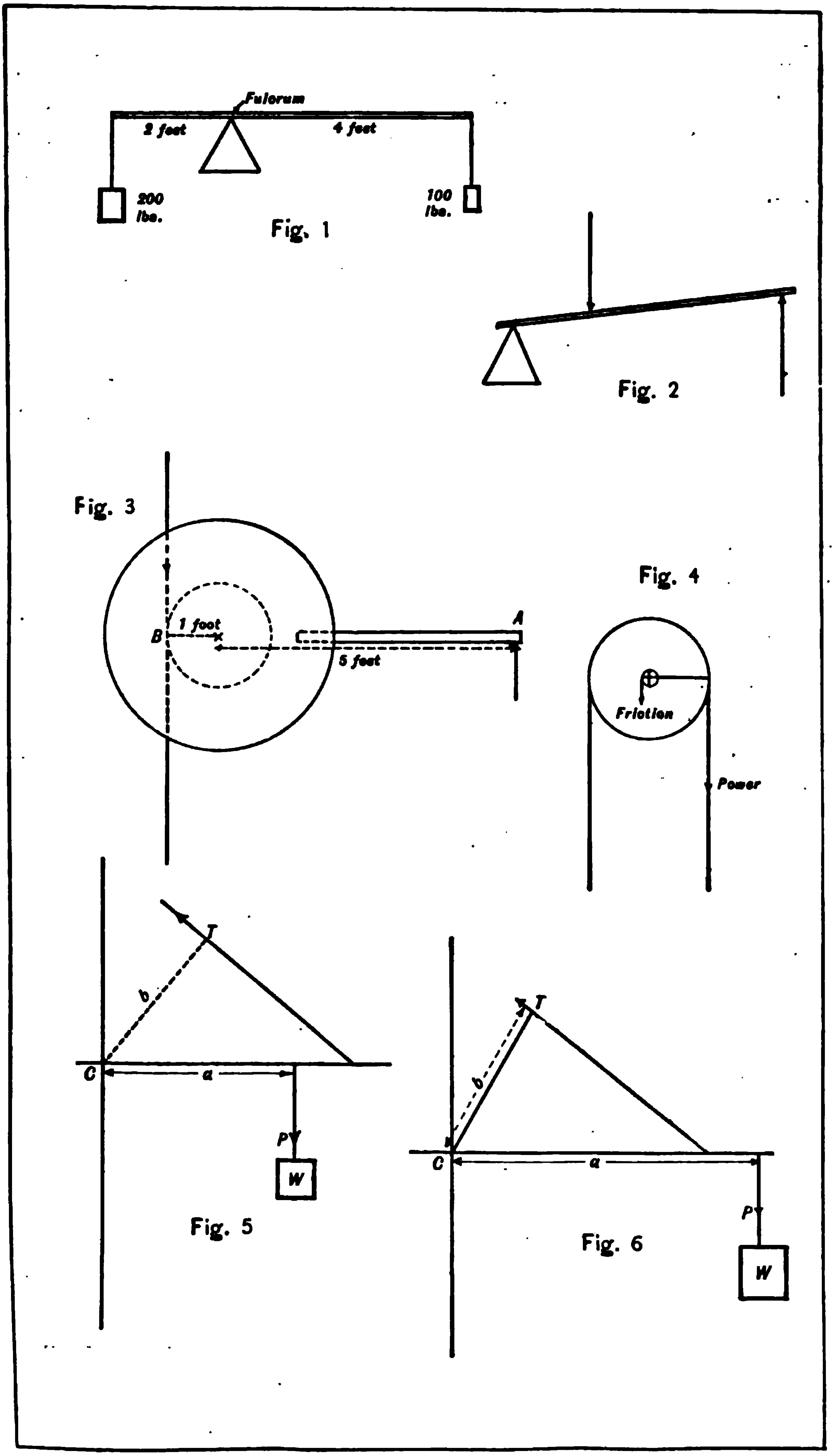
In Fig. 1, Plate 30, the moments of the forces opposed to each other are respectively 4×100 foot-lbs. and 2×200 foot-lbs.; and as these balance, the system remains at rest.

It is by creating a difference between opposing moments that force is multiplied by means of a lever; a small force being applied with a long arm to overcome a large force acting with a short arm.

It should be noted that the forces whose moments are opposed to each other may act on opposite sides of the fulcrum, as in Fig. 1 or on the same side, as in Fig. 2.

Perhaps the most familiar example of a lever on ship-board is the old-fashioned capstan (Fig. 3), the principle of which is preserved in the winches and windlasses of modern steamers. Another example of the lever, though one not always thought of as such, is the sheave of a block turning upon a pin by the tension

Plate No. 30.



THE LEVER

of a rope passing over its periphery (Fig. 4). Here the friction between the sheave and the pin constitutes a force opposing the tension of the rope, and we have two moments as indicated in the figure. This is (in part) the reason for the rule that sheaves should be as large as is conveniently practicable.

The principle of the lever is involved in all cases where a force is applied to a rigid body at a point other than the point of support; as for example, in the case of a weight suspended from a yard or a derrick at a point inside or outside the lift or burton. In Fig. 5 the weight is hung inside the lift and the downward pull is divided between the lift and the truss. To find the tension borne by each, we must apply the principle of moments. Considering the axis of the system as at C (the truss), we have for our equation of moments $aP = bT$, where a and b are the two arms, P the downward pull of the weight, and T the tension on the lift.

If the weight is suspended outside the lift, as in Fig. 6, the equation is, as before, $aP = bT$; and since in this case a is greater than before, while P and b are unchanged, it follows that T must be greater than before. That is to say, the farther out on the yard a weight is hung, the greater the resulting tension on the lift.

The Tackle.

There is no mechanical appliance of greater importance than the tackle, but as this is fully treated in the next Chapter, it will be omitted here.

It is important to note that in all mechanical appliances by which power is multiplied, the gain in power is purchased by a proportional sacrifice of speed. Thus in the capstan (Plate 30), the power applied at A is multiplied five times at B, but B moves only one fifth as fast as A. So in a tackle, as will be explained hereafter. And so in all cases where power is multiplied.

In all cases where yards, derricks, tackles, etc., are used for handling weights, it must not be overlooked that the weights of the spars, blocks, ropes, etc., are to be reckoned with in our calculations; the weight of each of these constituting a downward force acting at its individual centre of gravity.

CHAPTER VI.

BLOCKS AND TACKLES.

(Plates 31 and 32.)

§ I. BLOCKS.

A "Block," in the nautical sense, consists of a frame of wood or metal within which are fitted one or more sheaves or pulleys over which a rope may be led for convenience in applying power. If the block is properly used, it multiplies the power as explained in connection with Tackles. (§ II.)

As a rule, blocks are built up of several pieces of wood or metal riveted or bolted together.

Sheaves may be of metal or lignum-vitæ. If of the latter, their bearings are boushed with metal.

The *swallow* of the block is the space between the sheave and the frame, through which the rope passes. The side pieces of the frame are the *cheeks,* and the end of the block opposite the swallow is the *breech.*

A *score* is cut around the outside of the block to take the *strap,* which may be of wire rope or of wrought iron or steel. A hook or shackle is usually attached to the strap at one end of the block. The friction of a sheave upon the pin is an important factor in the efficiency of the block, as all power expended in overcoming this friction is wasted. For this reason blocks are often fitted with rollers or balls in the bearings for the pins.

The subject of friction will be treated at considerable length under the head of tackles, where it will be shown that a large sheave is essential for efficiency, and that the swallow should be large enough to prevent the rope from touching any part of the block except the sheave.

Special types of blocks are made for use with wire-rope.

Blocks take their names from the purposes for which they are used, the places which they occupy, or from some peculiarity in their shape or construction. They are further designated as single, double, treble, and four-fold, according to the number of their sheaves.

Various types of blocks are illustrated in Plates **31, 32, 33** and **35.**

Snatch-blocks are single iron-bound blocks, hooking to bolts on the deck to give a fair lead for boat-falls, topsail halliards, etc. The frame and strap are cut and hinged in such a way as to admit of "snatching" the fall, on the bight.

Gin-blocks, or *gins,* are iron pulleys (single) of large diameter, mounted in skeleton frames also of iron. Used chiefly for hoisting cargo, commonly with a wire-rope pendant.

Strapping Blocks. Rope is very little used on modern ships for strapping blocks, but wire-rope may sometimes be used with advantage, as being more reliable for a given calculated strength, than the iron work usually fitted. There is an especial advantage in this where very heavy weights are to be dealt with. For such work, a strap fitted with long lashing-eyes is recommended. Plate **35.**

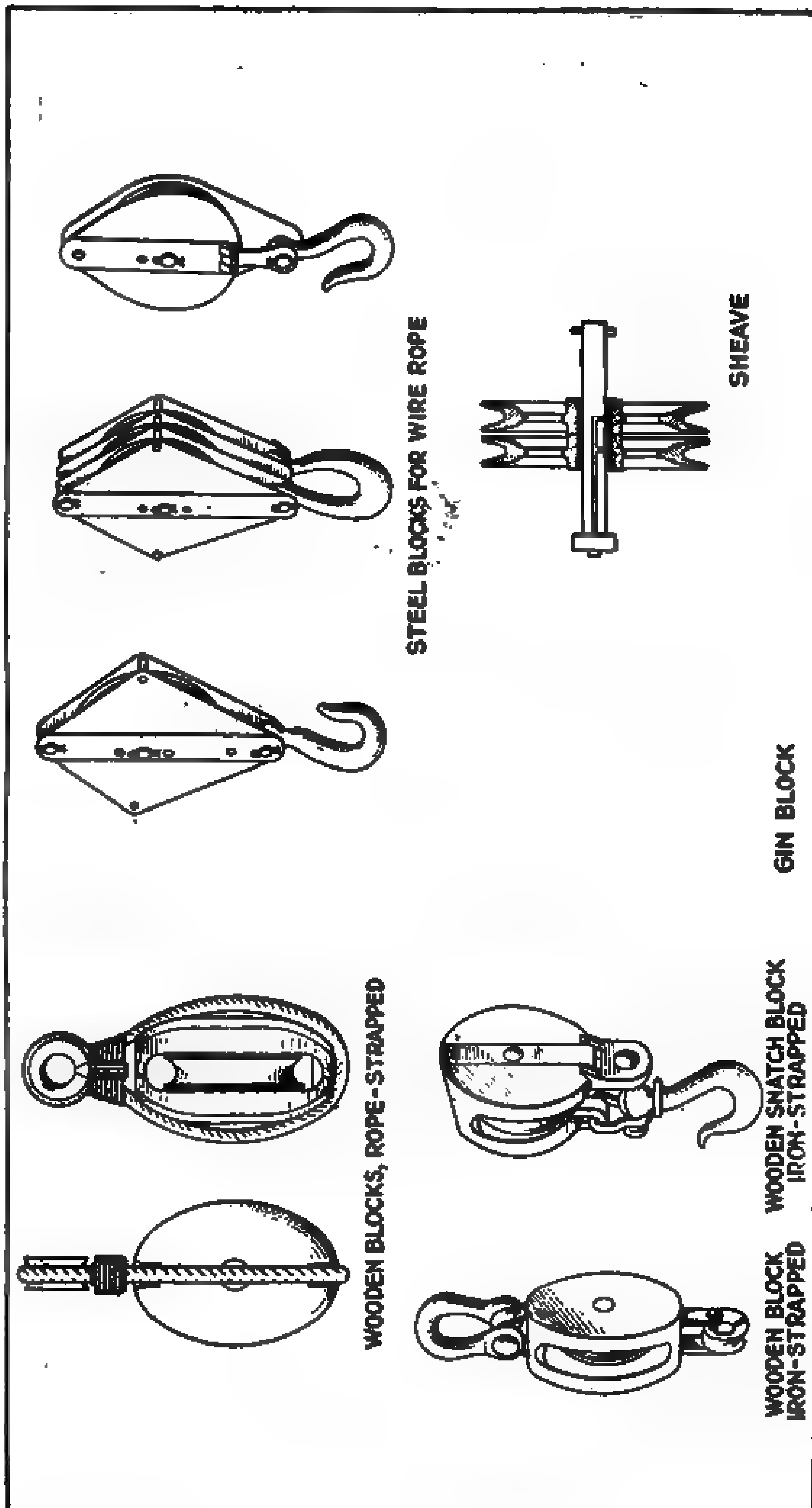
As to the strength of blocks, see § IV of this chapter.

§ II. TACKLES.

A combination of ropes and blocks for the purpose of multiplying power constitutes a tackle.

If we reeve a rope through a fixed block and apply power at one end to lift a weight at the other, we have a "Single whip," which is usually classed as a tackle, but gives no gain of power. If the block instead of being fixed is attached to the weight to be lifted, and one end of the rope made fast while power is applied to the other end, we have a tackle proper in its simplest form. Here (disregarding friction) the power applied to the hauling part is doubled at the movable block because it is transmitted around the sheave and so acts along both parts upon the mass to be moved. In the same way, the tension may be transmitted around any number of sheaves with a gain of power at each sheave of the movable block.

It should be noted that the tension is transmitted around the sheave of a fixed block exactly as it is around that of a movable one; but with no other effect in the case of the fixed block than to increase the pull upon the block and its supports. This point is often overlooked, but it is very important. If a weight of 100 lbs. is hanging from a yard-arm by a single whip *with both ends made fast to the weight,* the pull on the yard-arm is 100 lbs. If now we leave the weight hanging by one part of the whip and man the other part, or hold on to it, or make it fast to some other point than the weight, the pull on the yard is 200 lbs. The same point comes in with all


STEEL BLOCKS FOR WIRE ROPE
SHEAVE
GIN BLOCK
WOODEN BLOCKS, ROPE-STRAPPED
WOODEN SNATCH BLOCK
IRON-STRAPPED
WOODEN BLOCK
IRON-STRAPPED

BLOCKS.

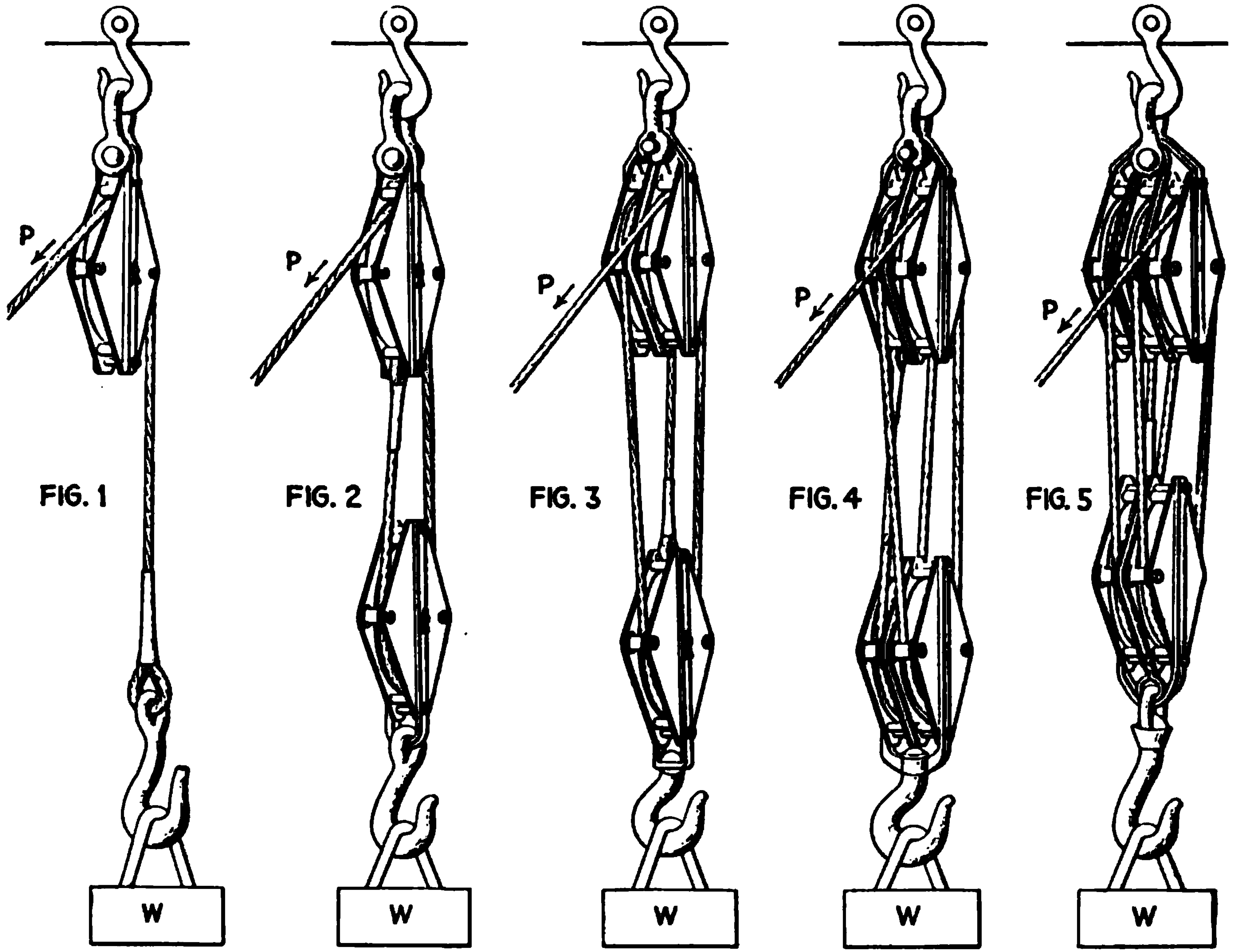


FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5

RATIO OF WEIGHT, W, TO POWER, P.

	Disregarding Friction	Allowing for Friction
Fig. 1	$P = W$	$\frac{P}{W} = \frac{11}{10}$
Fig. 2	$\frac{P}{W} = \frac{10}{20}$	$\frac{P}{W} = \frac{12}{20}$
Fig. 3	$\frac{P}{W} = \frac{10}{30}$	$\frac{P}{W} = \frac{13}{30}$
Fig. 4	$\frac{P}{W} = \frac{10}{40}$	$\frac{P}{W} = \frac{14}{40}$
Fig. 5	$\frac{P}{W} = \frac{10}{50}$	$\frac{P}{W} = \frac{15}{50}$

TACKLES.

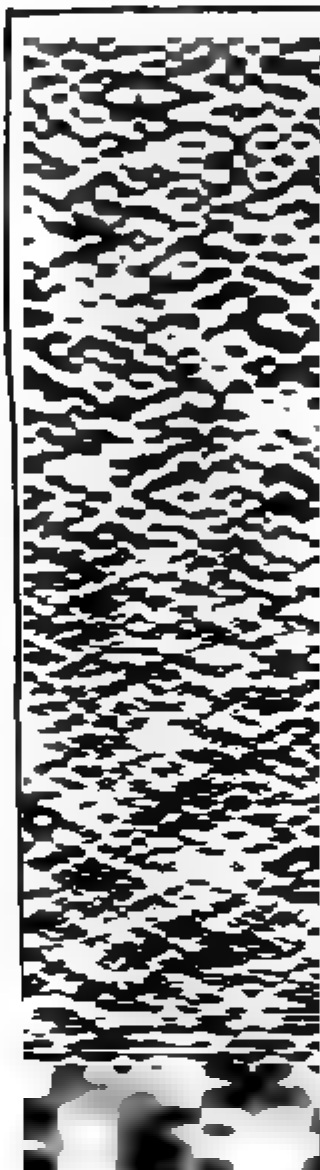


Fig. 1.
Single Whip.

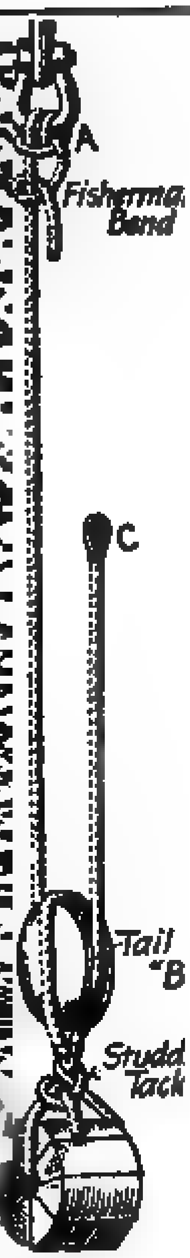


Fig. 2.
A Runner or
Single Whip Rever

Purchase.

Fig. 4.
Luff Tackle.

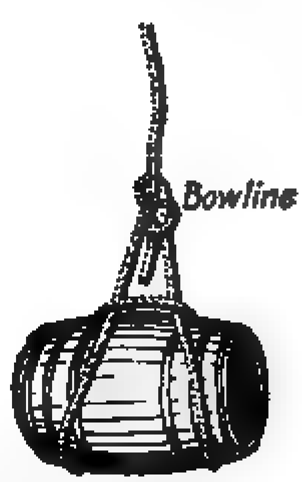


Fig. 5.
Cask Slung with the End
of a Single Whip.

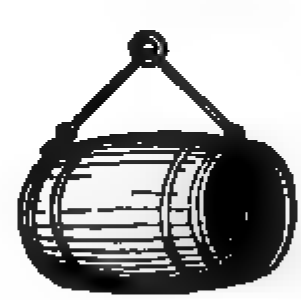


Fig. 6.
Cask Slung with Can Hooks.

TACKLES IN USE.

Plate No. 34.

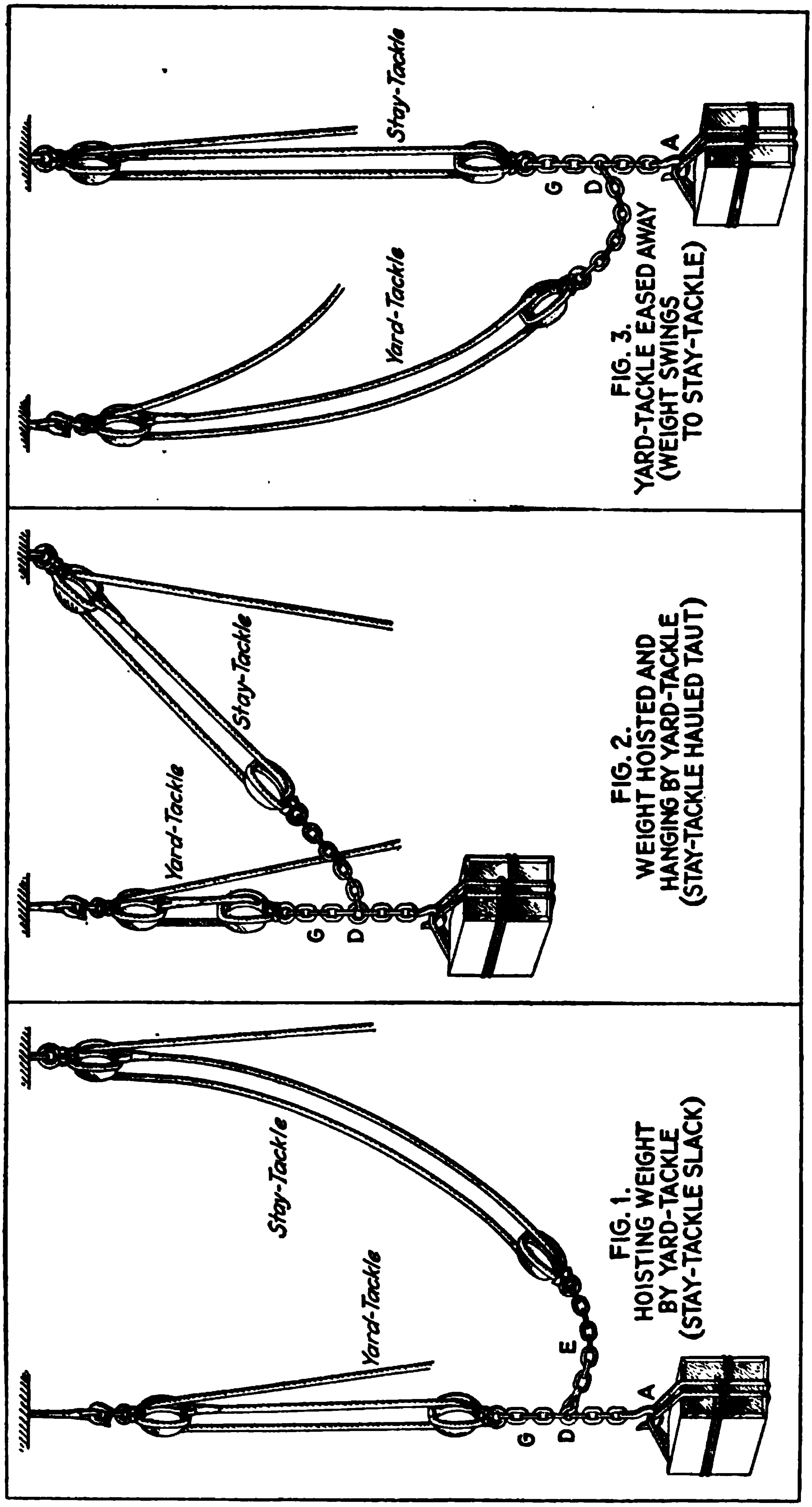
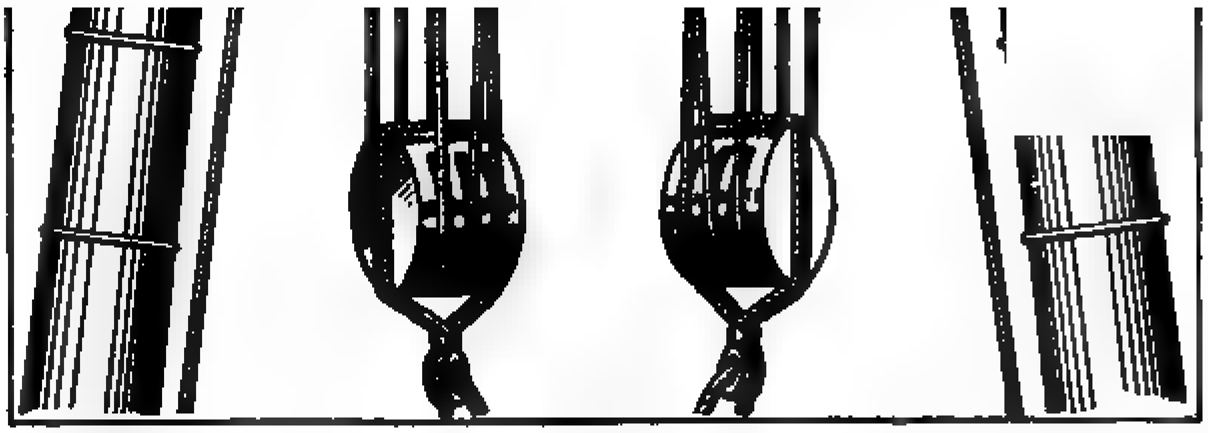


FIG. 1.
HOISTING WEIGHT BY YARD-TACKLE (STAY-TACKLE SLACK)

FIG. 2.
WEIGHT HOISTED AND HANGING BY YARD-TACKLE (STAY-TACKLE HAULED TAUT)

FIG. 3.
YARD-TACKLE EASED AWAY (WEIGHT SWINGS TO STAY-TACKLE)

YARD AND STAY TACKLES.



SHEARS WITH DOUBLE THREE-FOLD PURCHASE FOR HANDLING HEAVY WEIGHT.

NOTE. The rope straps shown in use for very heavy work should preferably be of wire. Even where iron-strapped-blocks are available they are less reliable than if strapped with wire rope, though they are, of course, more convenient.

purchases, but with less proportionate effect. If we have to find the tension on a yard or derrick to which a fixed block is made fast, we must add the tension on the hauling part to the direct downward pull of the weight.

Evidently, if we could neglect friction, we should have the simple rule that the power at the movable block is to the power on the hauling part, as the number of parts at the movable block is to one; but in practice this rule is modified by the work absorbed each time the rope passes over a sheave. This work is accounted for principally by the friction of the sheave upon its pin; but the bending of the rope around the sheave with the accompanying deformation of the fibres counts for something, and in wire-rope may be an important part of the total loss.

The stiffer the rope, the greater the loss from this source.

It results from this loss of power in passing around the sheaves that the tension on the successive parts of the fall grows less and less as we advance from the hauling toward the standing part and that the effective power of the tackle must be found by subtracting from the theoretical power, the proportion wastefully absorbed as above described. This proportion varies within wide limits; but it is always larger than is commonly supposed, increasing with the speed of working and with a decrease in the diameter of the sheave. It is reduced by low speed, and by the use of flexible rope and well-made patent blocks, having sheaves of large diameter as compared with the ropes they are to carry and kept in good order by frequent overhauling. If the rope touches the side of the block there is introduced a wholly unnecessary amount of friction with corresponding waste of power.

A small sheave, in addition to wasting power and increasing the wear upon the rope, introduces a direct and often fatal source of weakness by the difference in tension which it puts upon the successive layers of fibre from the inside to the outside of the bend, the outer layers being subjected to extreme tension while the inner ones are actually compressed. The result is that the outer layers give way and are followed by the others in succession toward the inside. This is the explanation also of the weakness in a sharp nip of any kind, whether due to a splice, a hitch, a bad lead or a bend around a pin or post.

Observe that whereas *in hoisting,* the maximum tension comes on the hauling part, *in lowering,* it comes on the standing part.

If the system is at rest, friction will tend to keep it at rest and

will reduce the power needed at either end to maintain equilibrium. Thus if we have a mass of 800 lbs. hanging from the lower block of a two-fold purchase, we should require 200 lbs. on the hauling part to maintain equilibrium if there were no friction; but since in practice there is and must be friction, we shall be able to prevent motion by much less than 200 lbs. As an extreme case, we may imagine the friction so great that nothing is needed on the hauling part to prevent the lower block from moving;—the weight of 800 lbs. not being sufficient to "overhaul" the tackle. Similarly a mass of 200 lbs. on the hauling part may be held at rest by much less than 800 lbs. on the lower block, the friction acting as before to prevent motion.

If we attempt, as a matter of convenience, to assign *an approximate numerical value to the loss by friction,* we shall find it convenient to represent this loss as a percentage added to the load; and experience shows that it is a safe general rule to increase the load by 10 per cent for each sheave over which the fall leads and then to consider that this increased load is being lifted by a frictionless purchase. Accordingly, to find the power required on the hauling part, or (what is the same thing) the maximum tension on the rope, we add the percentage for friction as above, and divide by the number of parts at the movable block. (See § IV.)

No attempt is made, in the above "Rule-of-Thumb," to take account of variations in speed due to variations in power applied, or of the fact that friction increases with the speed. The rule is for average working conditions, and includes a sufficient margin of safety to cover all practical cases.

It will be clear from the preceding that much power is wasted where the hauling part of a purchase is taken through an extra (fixed) sheave merely to give a fair lead. A familiar case of this is that in which a fall leading from aloft is taken through a block on deck to be manned or led to a winch. Such leads are often unavoidable; and even where not so, the gain in convenience may more than offset the loss of power; but it must not be forgotten that this loss of power is considerable. The same reasoning applies to an unnecessary sheave in the fixed block of a purchase, which has of course the same effect as an unnecessary sheave anywhere else.

If one tackle is attached to the hauling part of another, the power of the combination is the *product,* not the sum, of the powers of the tackles composing it.

It is important to observe that in tackles as in all other mechanical appliances, "*what is gained in power is lost in speed.*" This is clearly brought out by a comparison of Figs. 1 and 2 of Plate 32. In Fig. 1, a *single whip,* if the hauling part moves through one foot, the weight at the other end moves through the same distance. Both space and power are equal at the two ends of the rope. In Fig. 2, a *runner,* the power is doubled at the block, but the block moves through only half the distance moved by the hauling part. And so at every sheave of a movable block. If the power is multiplied six times, as by a three-fold block, the hauling part must move through six feet to move the block one foot. This may be a very important point where space is limited.

Tackles are of value not only as multiplying power but as applying the power more smoothly and uniformly. So, too, in easing away, they prevent the surging which is almost unavoidable with a single part, and at the same time make it possible to lower more slowly and with much more exactness; since, as has been explained, the motion at the block of a purchase is only a fractional part of what is given on the fall. The greater the number of parts to the tackle, the greater the gain in this respect as well as in the power.

For heavy work with a three- or four-fold purchase, it is well to reeve the fall with the hauling part leading from the middle sheaves of the blocks instead of from the outer ones. This involves a turn in the parts, but reduces the tendency of the block to cant. The hauling part of a tackle should be kept as nearly as possible parallel to the other parts. A divergence from this line means a loss of power.

As the power of a tackle depends upon the number of parts at the movable block, we have the rule that whenever circumstances permit, the block having the greater number of parts—or in other words, the block from which the hauling part leads—should be attached to the weight to be moved. This rule is often disregarded because it is usually impracticable to take the hauling part from the lower block directly to the winch; and the most natural way of giving it a lead from the derrick-head is to place there the block of the tackle from which this part leads. A better plan is to let the hauling part come from the lower block, and to take it up through an independent leading block at the derrick-head; thus preserving the full power of the tackle.

In many cases it is necessary to use still another leader at the heel of the derrick.

§ III.

Tackles as used on shipboard may be designated either according to the number of sheaves in their blocks; as, single, double, three-fold, etc.; or according to the purpose for which they are used; as, Yard-tackles, Stay-tackles, Fore-and-aft-tackles, etc. Still other designations, not so easily accounted for, are luff-tackles, gun-tackles, Spanish-burtons, etc.

Tackles are almost invariably rove of manila rope.

Plate 32 shows various forms of tackles with the theoretical gain in power due to each and the approximate actual gain when friction is taken into account. Plates 33 and 34 illustrate certain common applications of tackles on shipboard.

A *Single-whip* (Fig. 1, Plate 32). A single block, fixed.

A *Runner* (Fig. 2, Plate 32). A single block, movable.

A *Whip and Runner* would be a whip hooking to the hauling part of a runner.

A *Gun-Tackle Purchase.* (Fig. 3, Plate 32.)

A *Luff-Tackle* (Fig. 4, Plate 32). A single and a double block.

A *Luff upon Luff.* The double block of one luff-tackle hooked to the hauling part of another, thus *multiplying* the power.

A *Two-fold Purchase.* (Fig. 5, Plate 32.) Two double-blocks.

A *Double-Luff.* A double and a treble block.

A *Three-fold Purchase.* Two treble-blocks. (See Plate 35, in which two purchases are shown.)

A three-fold purchase is the heaviest purchase commonly used on shipboard.

The above are all the purchases in common use. The designations above given are descriptive of the character of the purchases, not of their use. It will be noted that in all cases where the two blocks of a purchase are alike, the hauling part leads from the block to which the standing part makes fast, while in cases where one block has an extra sheave, the hauling part leads from this block and the standing part from the other. *To get the full power of any of the purchases, the block from which the hauling part is led must be secured to the object to be moved.*

The following are some of the purchases commonly used, designated by terms descriptive of their use, without reference to the blocks or sheaves involved.

Relieving-Tackles are used to assist or replace the tiller ropes in steering. One block hooks to the tiller, the other to the ship's side.

Stock- and Bill-Tackles are used in getting the anchors on and off the bows in old-fashioned ships. They hook to straps on the stock and bill of the anchor respectively, and lead across the deck.

Thwartship-Tackles are used on the heads of boat-davits for rigging in. In a more general sense the term is applied to any tackle leading across the deck. Similarly, a tackle for hauling out the backbone of an awning or for any other purpose where it has a fore-and-aft lead is a *fore-and-aft* tackle.

Hatch-Tackles are used at hatches, for hoisting, lowering stores, etc.

Jiggers are small light tackles used for miscellaneous work about the ship.

A *Deck-Tackle* is a heavy purchase, usually two-fold, used in handling ground-tackle, mooring ship, and, generally, for heavy work of any kind about the decks.

Plate 35 shows a special purchase which may be used for very heavy weights. The tension on the various parts of the fall is partially equalized, by applying the power to both ends.

Yard and Stay Tackles take their names from their application on ships with masts and yards, where they were used together for transferring stores from a boat alongside, to the deck or hatch of the ship. The "yard tackle" was hooked at the yard arm, where it could plumb the boat, and the "stay tackle" was hooked to a strap aloft and amidships, usually on the collar of the mainstay, from which point it plumbed the main hatch. Plate 34, Fig. 3.

The general principle involved in the "yard and stay" is of wide application not only on shipboard but elsewhere, in cases where a weight is to be lifted and transferred to a point at no great distance. Assuming two points favorably placed for carrying the upper blocks of the purchases (Fig. 3) the weight is hoisted by the "yard tackle" (so called for convenience), to a suitable height, the slack of the "stay tackle" being taken in (by one man) and the fall belayed. The yard tackle is then slacked

away and the weight swings in and hangs by the stay tackle, ready to be lowered away.

Modifications, applications and extensions of this principle will readily suggest themselves.

Mechanical Purchases. (Plate 36.)

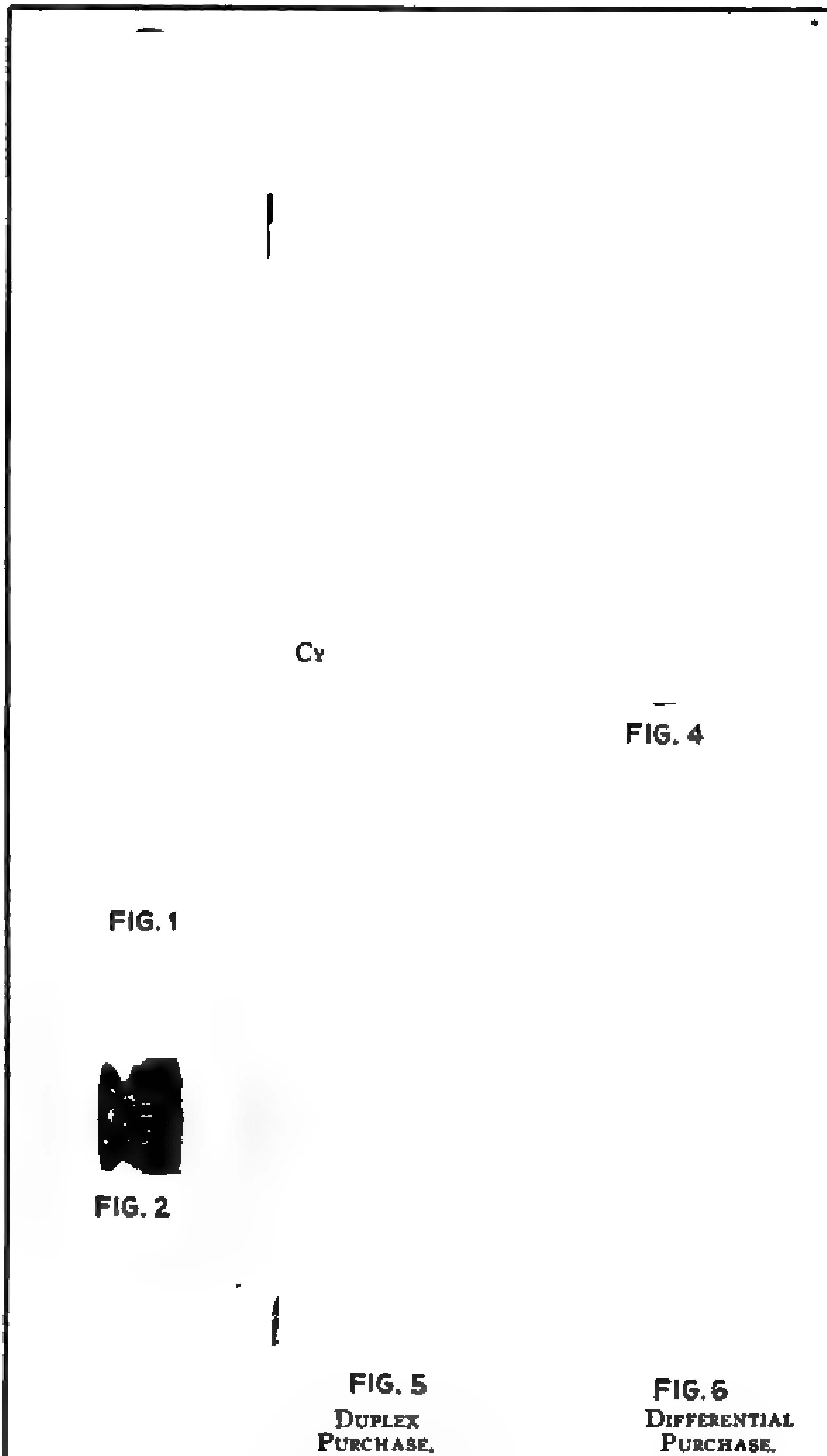
In a *differential purchase* (Fig. 6) an endless rope is taken over two sheaves of slightly different diameters which are keyed to the same shaft and revolve together. A movable block to which a weight may be attached is hung in the bight of the endless rope. If power is applied to one of the parts leading from the larger sheave, the rope is unwound from the sheave, but is at the same time wound up on the slightly smaller sheave alongside. Thus the change in the length of the bight which carries the movable block is very slight, for a great distance moved by the hauling part. By a simple mathematical demonstration, which would be out of place here, it can be shown that the ratio of the power applied, to the power on the movable block, is equal to the difference in the diameter of the sheaves of the fixed block divided by the larger diameter.

A *Duplex Purchase* (Fig. 5) consists of two wheels at right angles to each other, one of which has a cogged rim engaging a series of cams on the face of the other wheel. The details are made clear by the figure. The power here may be made almost anything that is desired, by proper design of the cams and gearing. In any given case it may be determined theoretically (without friction) from the ratio of the distance moved by the power to that moved by the weight.

Still another type of patent pulley is illustrated in Figs. 1, 2, 3. This type is much used in the Navy. Its working is as follows:

The lift wheel, that is the sprocket wheel which carries the lift chain, is cast in one piece with the spur-wheel that drives it. (Fig. 2.) This double wheel turns freely upon a hollow shaft rigidly supported at both ends in the frame. The spur-wheel is encircled by a yoke having internal teeth meshing into the spur-wheel teeth and driven with a gyrating movement about it by two eccentrics placed diametrically opposite (Fig. 3). The hand wheel shaft passes through the hollow main shaft, carrying at the further end a pinion which drives two spur-wheels, one on each of the two eccentric shafts (Fig. 4).

Plate No. 36.



MECHANICAL PURCHASES.

The number of the teeth in the spur-wheel divided by the difference between the number of the spur-wheel teeth and the number of the internal teeth of the yoke equals the number of revolutions of the eccentric necessary to turn the lift wheel once. (In the one-ton size, the spur-wheel has twenty-one teeth, the yoke twenty-four internal teeth, and the eccentrics turn seven times to each revolution of the lift wheel.) The eccentric shafts have bearings at both ends and roller bushed connection with the yoke.

The friction loss of this movement is so slight (the efficiency is about 80 per cent) that it has been found practicable to gear the hoists to a very high speed without increasing the hand wheel pull above that of other slower hoists.

The automatic brake permits the spinning of the hand wheel in either direction when there is no load, locks the load with perfect safety, and yet permits its free lowering by a very slight reverse pull on the hand chain.

§ IV. STRENGTH OF ROPES, BLOCKS AND TACKLES, ETC.

When definite information is at hand with regard to the strength of the rope in question, it should of course be utilized. In the absence of such definite information, the following rules are convenient and safe:

B = Breaking stress, lbs. or tons (of 2240 lbs.).
P = Safe working load; viz., safe tension for single part of rope.
C = Circumference (inches).

Rule 1. Strength of manila or hemp.

$$B = \frac{C^2}{2.5} \text{ tons} = C^2 \times 900 \text{ lbs.}$$

Rule 2. Strength of wire.

$$B = C^2 \times 2.5 \text{ tons} = C^2 \times 5600 \text{ lbs.}$$

The breaking stress being known either from the above formulae or from other sources (see appendix), the working load adopted as safe for a single part of the rope (P, Plate 32) will depend upon the factor of safety which we adopt after consideration of the condition of the rope itself and the use to be made of it.

The factor of safety may be taken as follows:

(a) Under average conditions,

Working load, P, = 1/6 breaking stress, B.

(b) Under best conditions—new rope to be used occasionally,

Working load, $P, = \frac{1}{4}$ breaking stress, B.

(c) Under unfavorable conditions, where rope is used frequently and for an indefinite period, as in the case of running rigging and boats' falls,

Working load, $P, = \frac{1}{8}$ breaking stress, B.

If, without knowing the breaking stress in a given case, we wish to derive the safe working load directly from the circumference of the rope, we have the following:

Rule 3. Safe working load for manila or hemp.

Under average conditions:

$$P = \frac{C^2}{15} \text{ tons} = C^2 \times 150 \text{ lbs.}$$

Rule 4. Safe working load for wire.

Under average conditions:

$$P = \frac{C^2}{2.5} \text{ tons} = C^2 \times 900 \text{ lbs.}$$

Under best conditions, add 30% to above values of P.

Under very unfavorable conditions, subtract 30% from above values of P.

NOTE.—Observe that the working load for wire is the same as the breaking stress for manila.

Rule 5. Strength of blocks.

It may generally be assumed that the safe load for a well-made *block* is in excess of that of any hemp or manila rope that it will reeve. This, however, is not always true of the *hook*, which is almost invariably the weakest part, and often gives way under strains for which the block is otherwise amply strong. The strength of the hook is therefore the measure of the strength of the block. The difficulty here comes from the tendency of the hook to open out;—a tendency which should be guarded against, in heavy work, by careful "mousing" of the hook—preferably by an iron link.

For heavy work, *shackles* are fitted to blocks in place of hooks and are very much to be preferred, as will be apparent from the rules and tables which follow.

(a) *Hooks.*

D = Diameter at back of hook.

$P = \frac{2}{3} D^2$ tons.

(b) *Shackles.*

D = Diameter at sides.

$P = 3 D^2$ tons.

NOTE.—For a given diameter of material, a shackle is approximately 5 times as strong as a hook.

The following table gives the results of practical tests made at the Watertown Arsenal. The hooks and shackles tested were of the ordinary commercial form. The diameter given is that of the metal at the back of the hook and the sides of the shackle.

TEST OF HOOKS.

Diameter of metal.	Broke at	Remarks.
½ inch	2,385 lbs.	Hook partly straightened, then fractured across the back.
¾ "	4,130 "	
1 "	10,815 "	
1¼ "	14,510 "	
1½ "	20,940 "	
1¾ "	27,420 "	
2 "	33,100 "	
2½ "	55,380 "	

TEST OF SHACKLES.

Diameter of metal.	Broke at	Remarks.
¾ inch	20,700 lbs.	Eye of shackle parted.
⅞ "	38,100 "	" " "
1 "	51,900 "	" " "
1¼ "	75,200 "	" " "
1½ "	119,980 "	" " "
1¾ "	146,400 "	Sheared shackle-pin.
2 "	196,600 "	Eye of shackle parted.
2½ "	210,400 "	" " "

Rule 6. To find the size of manila rope to lift a given load (in tons).

From Rule 3, above, we have

$$C \text{ (inches)} = \sqrt{15 \times P,} \text{ (tons)}.$$

Hence, multiply the load *in tons* by 15 and take the square root of the product for the circumference of the rope in inches.

Rule 7. To find the size of wire rope to lift a given load. (6 × 12 type, Plate 17.)

From Rule 4, above, we have

$$C \text{ (inches)} = \sqrt{2.5 \times P,} \text{ (tons)}.$$

Hence, multiply the load in tons by 2.5 and take the square root of the product for the circumference of the rope in inches.

Rule 8. To find the size of rope when rove as a tackle to lift a given weight.

Add to the weight one-tenth of its value for every sheave to be used in hoisting. This gives the total resistance, including friction. Divide this by the number of parts at the movable block, for the maximum tension on the fall. Reeve the fall of a size to stand this tension as a safe working load.

EXAMPLE:

To lift 10 tons with a three-fold purchase, the fall of which, coming from the upper block, is taken through an extra sheave on deck for a fair lead. Required the size of fall needed.

Total resistance, including friction $=10+7\times\frac{10}{10}=17$ tons.

Maximum tension on fall $=\frac{17}{6}=2.8$ tons.

Size of fall (Rule 2) $=\sqrt{15\times2.8}=6\frac{1}{2}$ inches (nearly).

Rule 9. To find the weight which a given purchase will lift with safety.

Find the safe-working load for the rope to be used (Rule 1). Multiply this by the number of parts at the movable block. This gives the total resistance including friction.

Multiply the total resistance by 10 and divide by 10 + the number of sheaves used. The result is the weight that may be lifted.

EXAMPLE:

To find the weight which may be lifted by a fall of 6½-inch manila rove as a three-fold purchase, the fall of which leads from the upper block through an extra leader on deck.

Safe-working load, $\frac{6.5^2}{15}=2.8$ tons $=P$.

Total resistance, including friction, $6\times2.8=16.8$ tons.

Weight to be lifted, $\frac{16.8\times10}{10+7}=\frac{168}{17}=10$ tons approximately.

Rule 10. To find the strength of a spar to resist compression (derrick or shears).

$T=$ Safe thrust in tons.

R = Radius of spar in inches.
L = Length of spar in feet.

$$T = \frac{4R^4}{L^2}.$$

NOTE.—The multiplier 4 in this formula is safe for all ordinary kinds of wood. For very strong woods, like oak, mahogany, etc., it could be increased 50 per cent without danger.

EXAMPLE:

To find safe thrust for a spar 10 inches in diameter, of fir, 17 feet long.

$$T = \frac{4 \times 5^4}{17^2} = 8.6 \text{ tons.}$$

NOTES.—Rule 6, above, gives an unnecessarily large factor of safety for the stronger types of wire, but it is convenient and safe.

A well-made splice weakens either manila or wire by from 5% to 10%.

A sharp nip may weaken manila or wire by from 25% to 50%.

Manila deteriorates rapidly if stowed away wet, or if exposed, either wet or dry, to continued high temperature.

Wire-rope should be discarded when its outer wires are worn down to one-half their original diameter.

The strength of two ropes of different sizes but similar construction is proportional to the *squares* of the circumferences. Thus a 2-inch rope is to a 3-inch as 4 to 9.

As a working rule, wire-rope is 6 times as strong as manila of the same size.

In cases where a load is applied suddenly, with a blow or a jerk, its effect is doubled, and this should be allowed for in calculating the size of rope required.

Plate No. 37.

OLD-FASHIONED MAST AND YARD RIGGED FOR HANDLING VERY HEAVY WENGHT.

Note.—The material here shown is obsolete, but the principles involved are clearly indicated and of universal application.

CHAPTER VII.

HANDLING HEAVY WEIGHTS.

§1.

Where masts and yards are available, as in sailing ships and steamers with auxiliary sail power, the problem of handling weights presents no great difficulty. The lower yards are used as derricks, with suitable support from the mast by lifts and tackles. The principles which govern the rigging of these are identical with those discussed theoretically in Chapter V, and practically in §2 of the present Chapter. Unfortunately no such facilities as are here assumed exist on modern ships. Yards are non-existent and masts are not always so placed as to be available. When they are available, they are in some ways more useful than the masts of sailing ships, because so much stiffer. A span can often be used between the masts to furnish a point for hooking a tackle just where it is wanted (Plate **29**); and the place of the old fashioned yard, for carrying a tackle that shall hang clear of the ship's side, may in many cases be supplied by a cargo boom or a boat-crane.

In spite of the fact that masts and yards of the type shown on Plate **37** are not found on modern ships, the plate has been retained because it illustrates *principles* which are as significant to-day as they were half a century ago and shows them more clearly than they could be shown by almost any other sketch that could be devised. Every tackle and every spar shown in the plate represent a *force* either of action or of re-action. The downward pull of the weight *W* is met by the upward reaction of the tackles, *a*, from the mast head, assisted by the spar, *S*, whose heel rests upon the deck, supported by *shores* from the decks below. The tendency of the spar to buckle is met by a brace *B* from its midship point to the mast. The inward thrust of the yard resulting from the horizontal component of the forces represented by *W* and *a* is met by the rolling tackles *cc*, the lower one of these contributing at the same time, through the leverage of the yard, to the support of *W*. The inward thrust of the yard is of course still further met by the cross-lashing which binds the yard to the mast. Of especial significance is the hawser

on the off-side, leading from the topmast-head to the side of the ship and in through a port to the mast between decks, and acting against the tendency of *w* and *a* to pull the mast to their side. The *shores* which brace the bulwarks against the thrust of this hawser are also to be noted.

An application to this case of the rules and examples given in § II of this Chapter will be found extremely instructive; and while the *materials* here shown may never be duplicated in practical experience, the *principles* (or some of them) will be duplicated in every problem that presents itself where heavy weights are to be handled.

Parbuckling (Plate 38). Where the object to be handled is of such a nature as to admit of *parbuckling,* this is a simple and convenient method to use, especially on a ship of low free-board. This is a characteristically naval method, and comes in conveniently in any case where an object of generally cylindrical shape is to be hoisted or dragged. A typical example is that of landing guns on a shelving beach, the guns being carried into shallow water by boats and rolled overboard onto hawsers which have been laid off at right angles to the beach, the ends of the hawsers being then brought ashore, over the gun, leaving the gun in the bight. The operation will be much simplified if the chase of the gun is built up by some convenient method to the diameter of the breech.

Cargo Booms (Plate 39) are secured to a mast by heavy pivot-bolts and supported by topping lifts and guys which admit of plumbing any point within a considerable range on deck and alongside. There is no difference in principle between such a boom and a yard rigged and used as in Plate 38, except that the yard has the characteristics of a long boom used nearly level. The cargo booms of merchant vessels and the boat-booms or cranes of men-of-war, are usually heavy enough for weights up to three or four tons, while the cranes of a Dreadnought are designed to handle boats weighing as much as 25 tons.

The range of power of such a boom may be considerably extended by the use of a spar as in Plate 39 to take the direct downward thrust, the deck under the shoe of the spar being well shored up. This takes a large part of the tension from the topping-lift. For very heavy weights, it is well to block up under the pivot-bolt, or to unkey the boom and step the heel upon

FIG. 1.
PARBUCKLING A SPAR ON BOARD SHIP

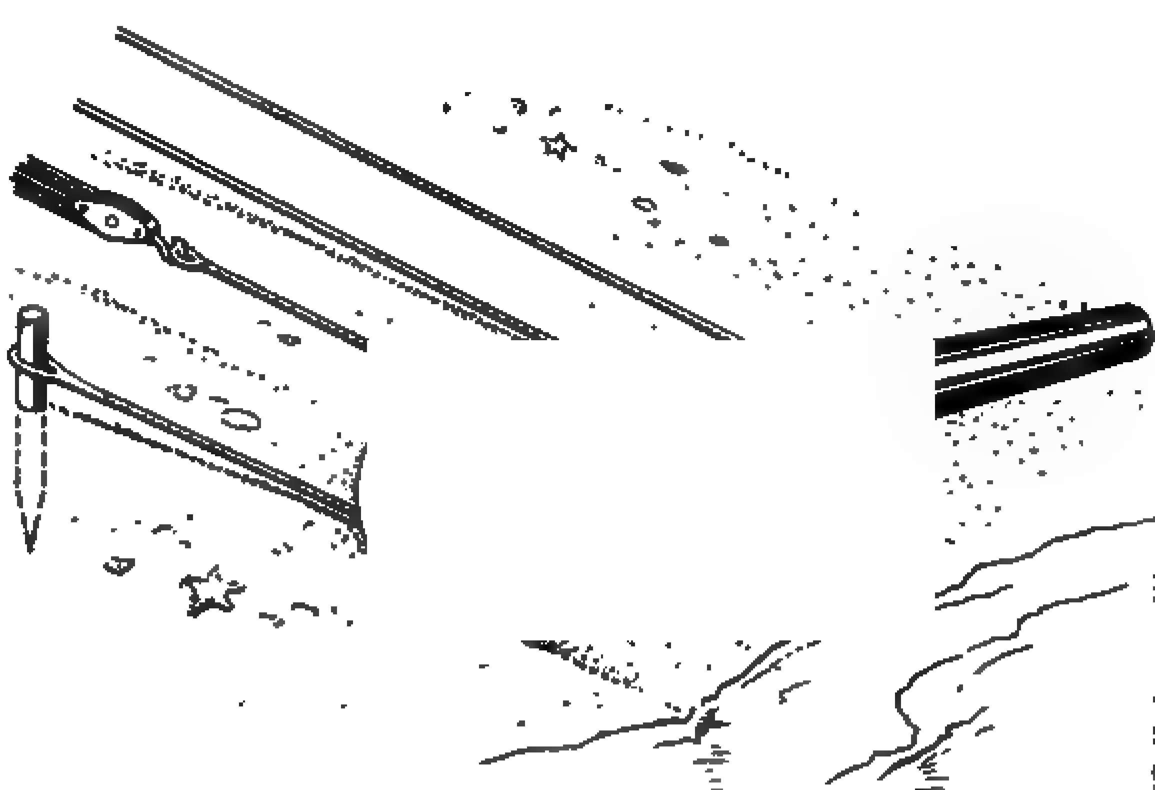
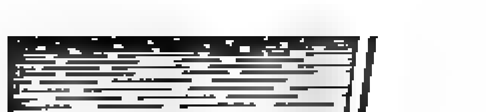
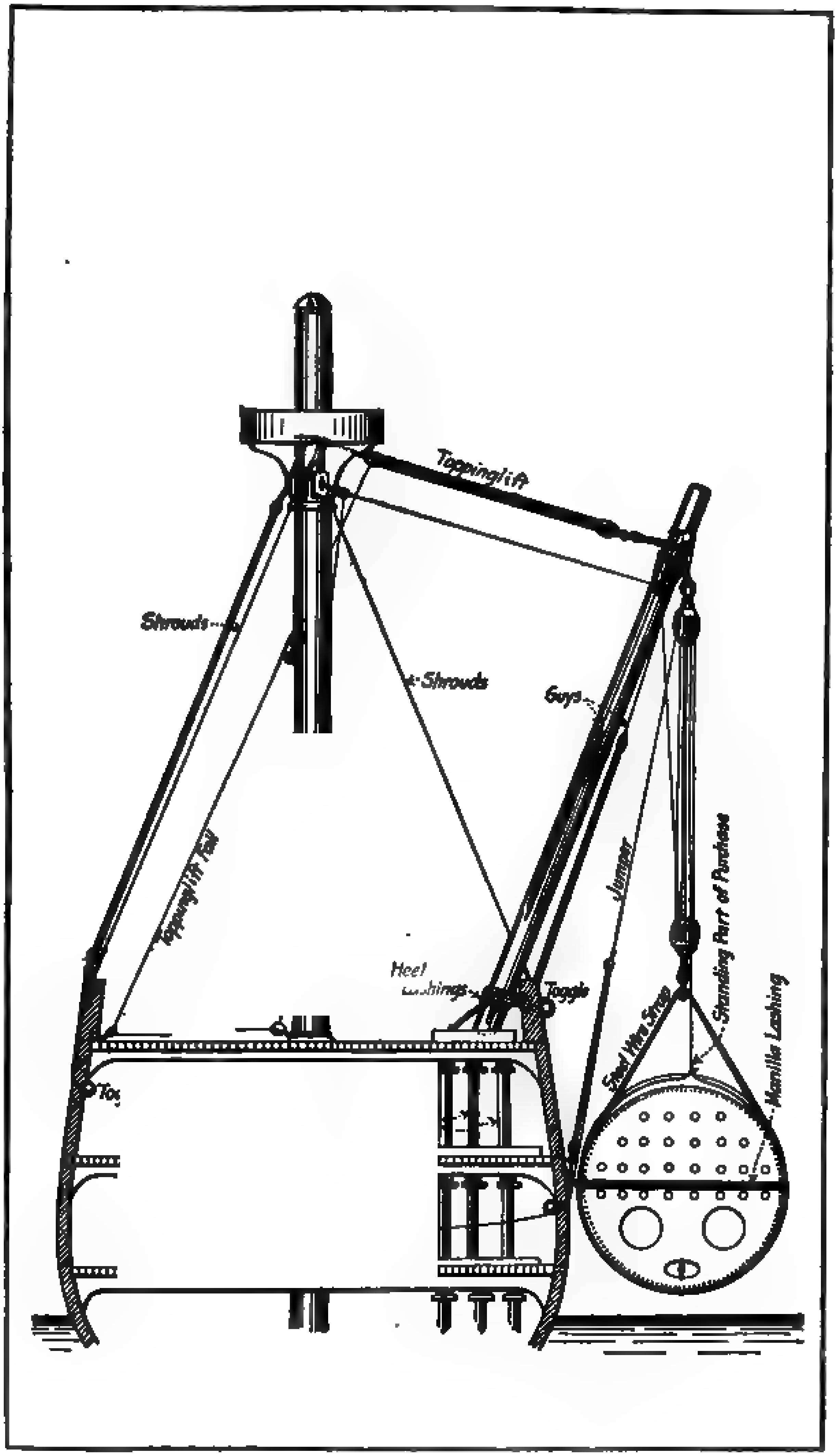


FIG. 2.
PARBUCKLING A GUN UP A BEACH

PARBUCKLING.



BOOM FOR HEAVY WEIGHTS.



RIGGING A DERRICK FOR A HEAVY WEIGHT.

the deck. The boom itself may be strengthened by "fishing"; that is, by placing lighter spars along its length and lashing all securely together. If the boom is not conveniently situated for the work to be done, it may be transported to the point where it is needed and supported there by topping-lifts and guys, the heel being placed in a shoe and the deck below shored up as in all similar cases. (Plate 40.)

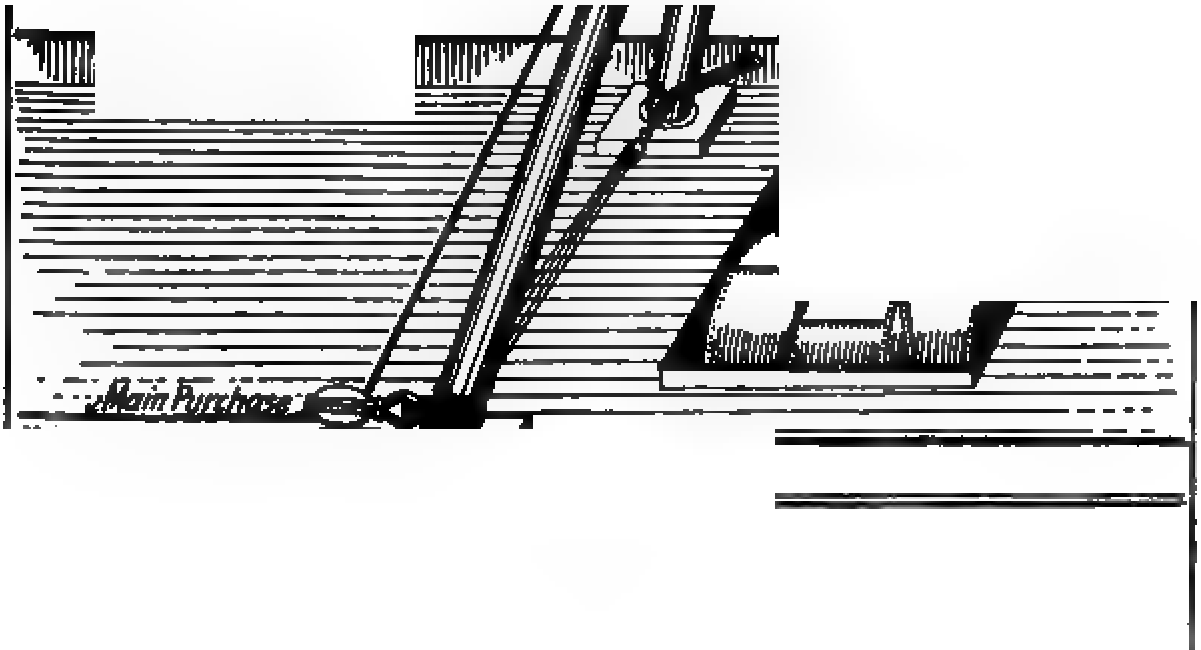
If the boom is to be topped up or lowered with the weight hanging from it, the strength of the topping-lift must be calculated for the lowest position the boom will occupy, as this is the one in which the demand upon it will be a maximum. It must be remembered also that in actually moving the boom there will be a much greater tension on the fall of the topping-lift than if the boom were fixed. This is due to the resistance of friction which must be added to the theoretical load as soon as the system is set in motion. (See Chapter VI.)

The anchor-davit may sometimes be utilized, assisted by a topping-lift from aloft if the fore-topmast is so situated as to make this feasible.

Where the ordinary resources of a ship are insufficient for the work in hand, a derrick or shears must be rigged, the materials being obtained where they can be found. Plate 40 shows the details of a derrick and Plate 41, those of shears.

The heels of such derricks and shears are stepped in shoes, which must be large enough to distribute the weight over a number of beams, and the decks below are well shored up. The shoes are lashed to prevent slipping, and in the case of shears are held from spreading by a thwartship tackle. The shear-head lashing is sometimes passed with figure-of-eight turns, but the method shown in Plate 41 is better. The lashing, being passed with the legs laid alongside each other, tautens as they are opened out. The shear-head is supported by topping-lifts and inclined as much as may be necessary. The more nearly upright the legs can be kept, the greater will be the proportion of the weight supported by the thrust of the spars and the smaller the demand upon the topping-lifts. The greater the distance from the heel of the derrick to the point where the guys set up, the less the strain upon the guys.

If the weight has first to be lifted from between-decks and afterward put over the side, it will usually be necessary to land



SHEARS FOR HANDLING A HEAVY WEIGHT.

it between the two operations. It is true that derricks (not shears) are constantly used to lift weights and swing them around, but these are derricks properly fitted and supported for it. With improvised arrangements and a heavy weight, it is wiser to land the weight and move the derrick or shears.

If it becomes necessary to rig the shears or derrick at a point where no mast is available for giving a lead to the topping-lift or guys, a mast may be improvised; the topping-lift being secured to this or led over it (through a good block) and set up as far from the mast as possible. Where the guys are to lead athwartships, an outrigger may be used on the off side of the ship, secured by a hawser dipping under the keel, and steadied by good lines forward and abaft.

If not entirely sure that everything is going to hold, it is well to block up from deck to deck with heavy planks crossing the hatches under the object as it is hoisted from below, and following up as close to it as possible, so that it cannot drop more than a few inches if anything gives way. So in transporting it from the hatch to the rail it should be lifted only just high enough to clear the deck. If it must be raised for the purpose of clearing the rail, skids may be used from the hatch and the weight partly lifted and partly skidded across.

If the blocks and falls that must be used are not heavy enough for the work required, with the fall rove in the usual way, resort may be had to the form of a tackle shown in Plate 35. Here we have two tackles so far as power is concerned, but by making the fall continuous and using both ends of it for hauling, we distribute the friction more uniformly, since there is no "standing part." Another advantage is, that in cases where two distinct tackles are used there must be times when one will lag behind, leaving the weight entirely on the other. This cannot happen where the fall is continuous, as in Plate 35. It is thus possible with blocks and falls of a given size, to handle a weight considerably heavier than would otherwise be safe.

All blocks should be thoroughly overhauled, and careful calculations made of the stresses to which all parts of the system are to be subjected. Shackles or lashings should be substituted for hooks whenever it can be done, and in other cases the hooks should be securely moused. Particular attention should be given to the running of winches to see that no surging is allowed in

either hoisting or lowering. A heavy surge will nearly or quite double the strain.

Finally, in reeving the purchases, leading the falls, etc., attention should be given to the principles explained, and the rules laid down, in Chapters V and VI.

Plate 33 illustrates a variety of methods of slinging weights, hooking tackles, etc.

Plate 42 shows a number of *Stoppers* and *Strops* for use in connection with ropes and tackles where heavy stresses are to be dealt with, whether for handling weights or for other purposes.

Fig. 1. A **Manila stopper** on a Manila rope, to take the strain while the rope is being belayed. The end of the stopper is usually held against the rope by the hand but it may of course be secured by a few turns of small stuff.

Figs. 2 and 3. A **Racking stopper,** binding the parts of a tackle together and jamming them. This is a handy method for stoppering a boat's fall for belaying.

Fig. 4. A **Manila strop on a manila rope,** for hooking a tackle.

Fig. 5. A **Chain Stopper on Wire Rope.** One of the most serious problems connected with the use of wire rope is that of holding a large rope (a hawser) by means of a stopper. Where the diameter of the rope does not much exceed an inch, it can be held against a moderate pull by a good manila stopper as in figure 1, but the strength of manila does not approximate that of wire and this will not do for holding against a really heavy strain.

A stopper of chain, like that of Fig. 5, is stronger than manila but does not grip so tightly.

Fig. 6. A **Ring Stopper** is sometimes useful, especially when the wire is to be checked while running out, but it has a tendency to put a kink in the wire.

Another problem connected with the use of wire rope, and especially of hawsers, is to provide a strop for hooking a tackle to the body of the rope. Here again the methods used with manila will answer fairly well for a small line and a moderate pull. With these conditions a manila strop may be used with wire in the same way as with manila. (Fig. 4.) But no manila strop will hold a large wire hawser under a very heavy pull, whether for hooking a tackle or for stoppering. It may be that

FIG. 2.

FIG. 4.
STRAP
ON A ROPE
(For Hooking a Tackle)

FIG. 3.
A RACKING STOPPER

FIG. 5.
CHAIN STOPPER ON WIRE HAWSER

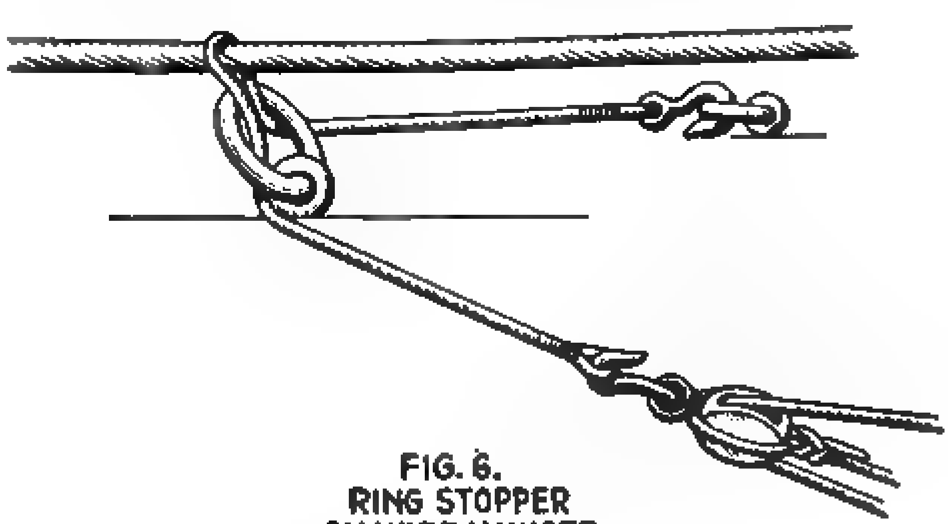


FIG. 6.
RING STOPPER
ON WIRE HAWSER

STOPPERS AND STRAPS.

the fibre-clad wire-rope shown in Fig. 6 of Plate 17 would be found effective.

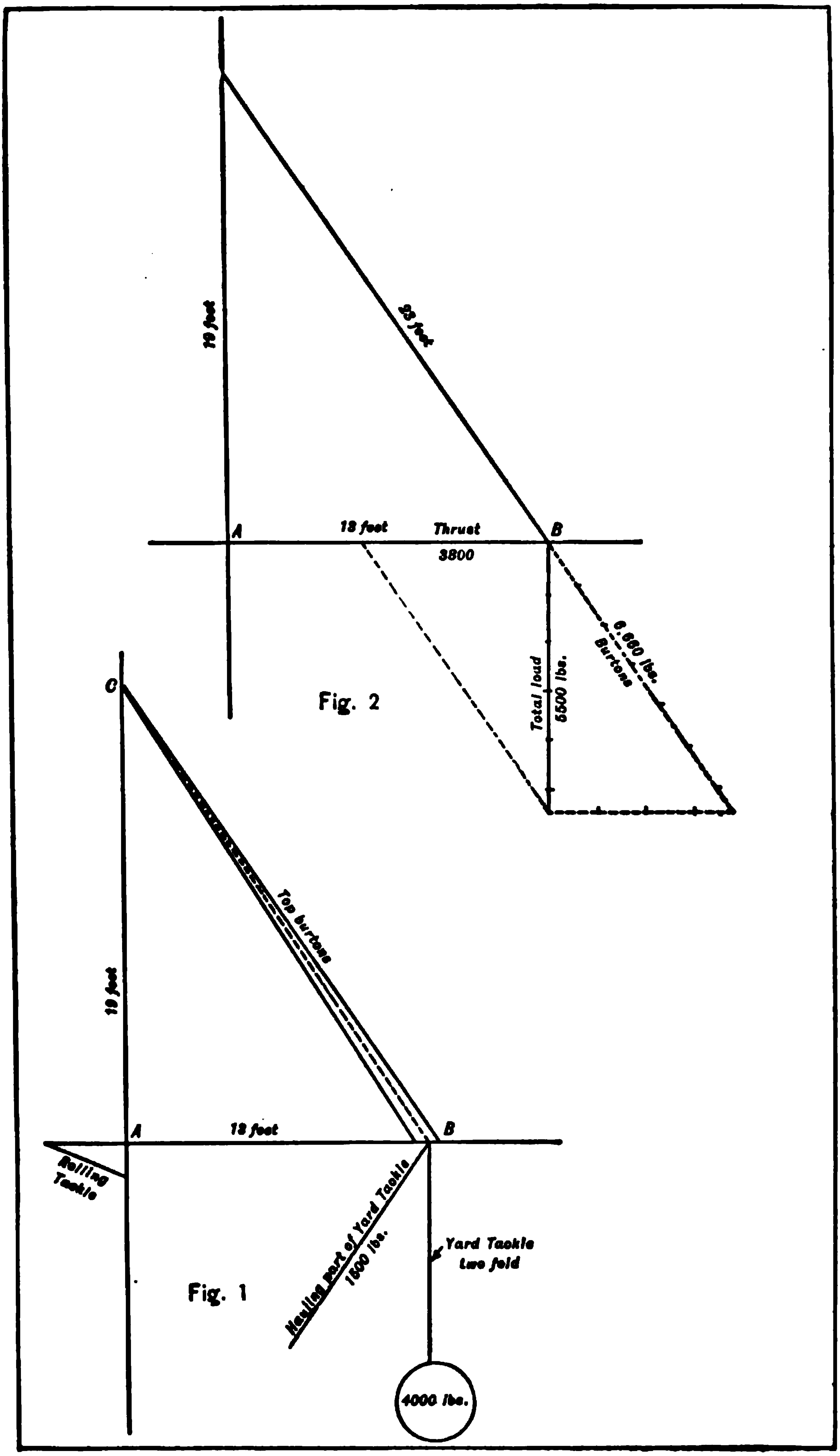
§ II. PRACTICAL EXAMPLES IN HANDLING WEIGHTS. (See Rules of Chapters V and VI.)

As the Rules above referred to are only approximations, it is unnecessary in applying them to work with mathematical exactness. In the solutions which follows, small fractions are neglected, but care is taken to keep, upon the whole, on the side of safety.

In many cases, a close estimate of the stresses can be made by the eye, without calculation, and it is well to accustom the eye to such estimates by an occasional test. Most of the calculations which are required can be made mentally, if the rules are well in mind. In important cases, however, it is worth while to make a careful sketch, to scale, and this will be found to involve very little trouble in comparison with the importance of the results depending upon it.

It is very important to remember that the *sudden* application of a load causes strains which may be double those produced by the same load applied gradually, or supported statistically. A rope that is capable of handling a steady load with perfect safety may give way at once, if, the rope being slack, the load is dropped, bringing up with a jerk on the suddenly tautened line. A case in point is that where a boat, having been hooked on for hoisting, is lifted by a wave, slacking the fall, and then drops back, tautening the fall with a jerk. A similar effect results when the slack of a crane-pendant is suddenly taken up by throwing the throttle of a winch wide open, or where a rapidly moving load is suddenly arrested.

The shorter the rope the greater the danger in cases like those cited above. In a very long rope, the "give" of the successive coil-like turns is cumulative and affords a relief which is lacking in a shorter rope. Similarly, the "give" of a tackle affords relief which is lacking in a single pendant.



HANDLING WEIGHTS BY A YARD.

1.

A weight of 4000 lbs. is to be lifted by a yard, as in Plate 43, the yard-tackle to be a two-fold purchase, with the hauling-part leading from the upper block to the deck. Two top-burtons of 3-inch manila are available for supporting the yard. It is required to calculate the size of rope required for the yard-tackle, and to determine whether the top-burtons are heavy enough for the work.

(a) Total resistance of main purchase including friction $= 4000 + \frac{5}{10}4000 = 6000$ lbs.

Maximum tension on fall $= \frac{6000}{4} = 1500$ lbs. $= \frac{3}{4}$ ton (nearly).

Size of rope for $\frac{3}{4}$ ton $= \sqrt{15 \times 0.75} = 3\frac{1}{2}$.

(b) The load on the yard is the actual dead weight, plus the tension on the hauling part[1] $= 4000 + 1500 = 5500$ lbs.

To find the tension on the lift, we construct the parallelogram of forces, as in the figure.

Tension of the topping-lift $= 6660$ lbs.

Or we may note the length of the lift and of the mast (from A to C), and determine the tension by a proportion, thus:

Length of mast, AC $= 19$.
Length of lift, BC $= 23$.
Downward tension at B $= 5500$ lbs.
$\frac{\text{Tension on lift}}{5500} = \frac{23.}{19.}$
Tension on lift $= 6660$ lbs.

It should be possible to estimate this tension rather closely by the eye, without calculation, since it is easily seen that the lift is not far from $1\frac{1}{4}$ times as long as the mast.

The tension will be divided between two top-burtons, each of which has three parts. As the yard is not to be moved, friction does not enter the problem. Each part will have to support one-sixth of the total tension, or, 1110 lbs. ($\frac{1}{2}$ ton).

To find the safe load for the rope of which the burtons are rove. Safe load for 3″ rope $= \frac{3 \times 3}{15} = \frac{6}{10}$ ton. (§IV, Chap. VI,)

As this is more than the tension found above for each part, the burtons are heavy enough for the work.

[1] Strictly speaking, only the vertical component of the tension on the hauling part should be included here, but it is convenient and safe to count it as if the lead of the hauling part were vertical.

(c) To determine the thrust on the yard.

Referring to the parallelogram of forces in Fig. 2, we have, Thrust $=3800$ lbs.

Or we may calculate it by proportion, as follows:

$$\frac{\text{Thrust on yard}}{5500}=\frac{AB}{AC}=\frac{13}{19}$$

Thrust $=3800$ (about).

Here again it should be possible to make a close estimate by the eye, without calculation.

This thrust is supported by the truss, the lift, and the rolling tackle. By unkeying the truss and slacking the lift we may throw it entirely on the rolling tackle, which we will assume to be a two-fold purchase with the double block hooked to the yard. This gives 5 parts to divide the thrust.

Tension on each part $=760$ lbs. $=0.33$ ton.

Size of fall for this tension $=\sqrt{15\times0.33}=2\frac{1}{4}$ inches (about).

NOTE.—This assumes that the rolling tackle is parallel with the yard. If the strap on the mast is below the yard, we find the tension on it by the parallelogram of forces.

2.

To lift 12 tons by sheers, as in Plate **44**.

Sheer-head Purchase.—Three-fold, with the hauling part leading from the upper block, parallel to the sheer legs, and through a leader on deck. Two (single) guys are used, making an angle of 30° with each other.

Total resistance $=12+\frac{7}{10}12=20.5$ tons.

Maximum tension on fall $=\frac{20.5}{6}=3.5$ tons.

Size of fall required $=\sqrt{15\times3.5}=7\frac{1}{4}$ inches (nearly).

To find the tension on the sheer-head, we neglect the tension on the hauling part of the sheer-head purchase, because this part leads parallel to the sheer-legs (where it adds to the thrust).

Load on the sheer-head $=12$ tons.

By the parallelogram of forces we find,

Total tension on the guys $=15$ tons. (Fig. 2.)

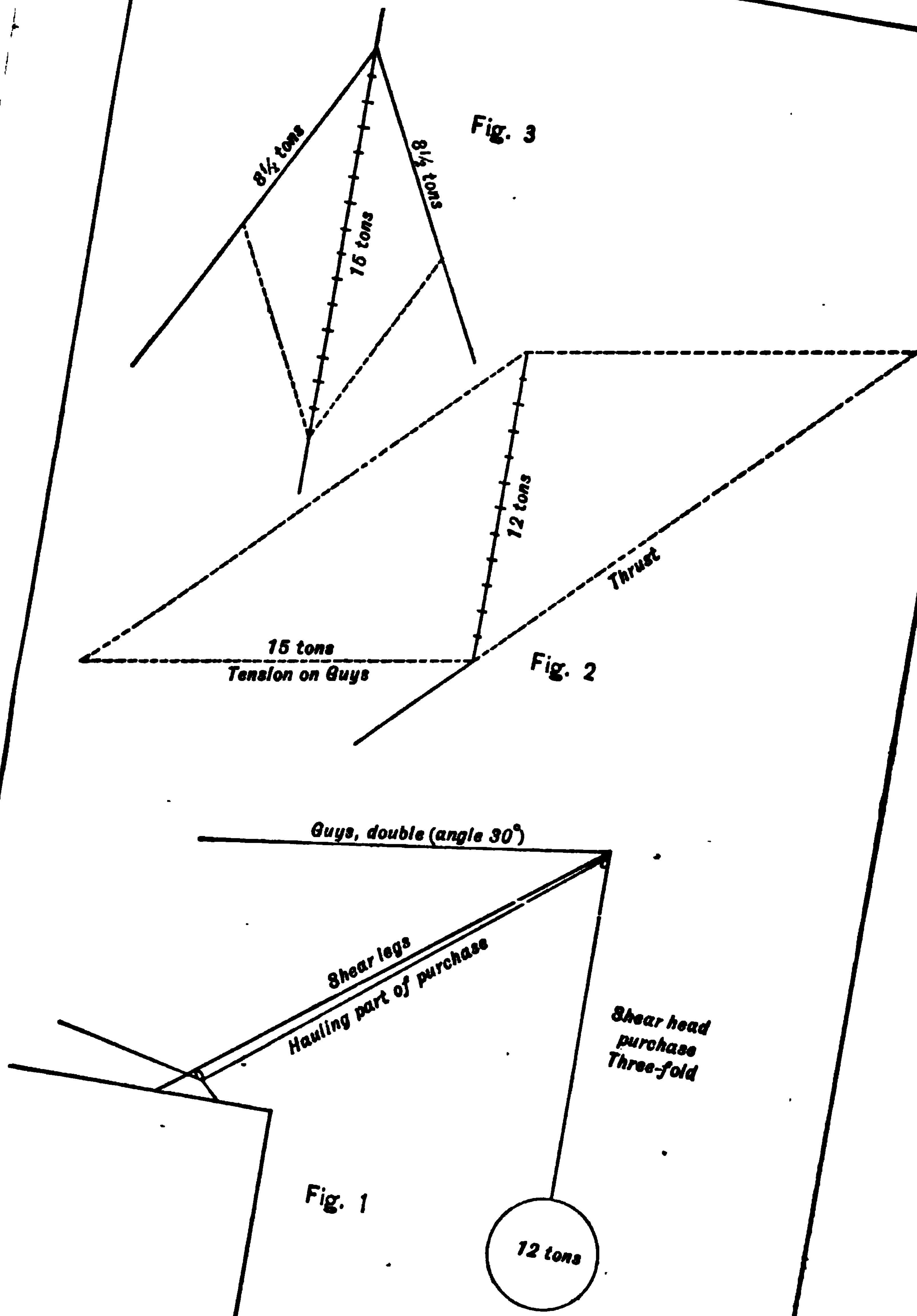
The tension on each guy $=8.5$ tons. (Fig. 3.)

The size of rope to support this tension,

$=\sqrt{15\times8.5}=11\frac{1}{4}$ inches for manila $=5$ inches for wire.

12-inch hawsers are required for the guys by the above rules if

Plate No. 44.



HANDLING WEIGHTS BY SHEARS

of manila. It should be noted, however, that these rules are formulated for conditions very different from those of the present case and that they involve a factor of safety which is unnecessarily large for a standing rope to be used for a short time. For a case of this kind, we may safely reduce our multiplier to 8. Thus:

Size of rope $=\sqrt{8\times 8.5}=8$ inches (about), for manila $=4$ inches for wire (approximately).

3.

It is required to lift a 10-ton boiler by a derrick as in Plate **45**, the boom to be topped up for landing the weight on deck.

Main purchase. Three-fold, the hauling part leading from the lower block, up through a leader at the boom end, then through a leader at the masthead, then through a leader on deck.

Total number of sheaves $=9$.

Number of parts at the movable block $=7$.

Topping-lift. Three-fold, the hauling part leading from the upper block, and through a leader at the foot of the mast.

Total number of sheaves $=7$.

Number of parts at the movable block $=6$.

(a) To find the size of fall for the main purchase.

Total resistance including friction $=10+\frac{9}{10}10=19$ tons.

Maximum tension on fall $=\frac{19}{7}=2.75$ tons.

Size of fall required $=\sqrt{15\times 2.75}=6\frac{1}{2}$ inches (nearly).

(b) To find the size of fall for topping-lift.

The load on the boom is the dead weight of the boiler alone, diminished somewhat as a result of the fact that the standing part of the main purchase leads up to the masthead. It is safe and convenient, however, to consider the whole weight as hanging from the boom. In resolving this along the lines of the lift and the boom we take the boom at its lowest point, this being the point at which the load on the lift will be a maximum.

Resolving the forces (Fig. 2).

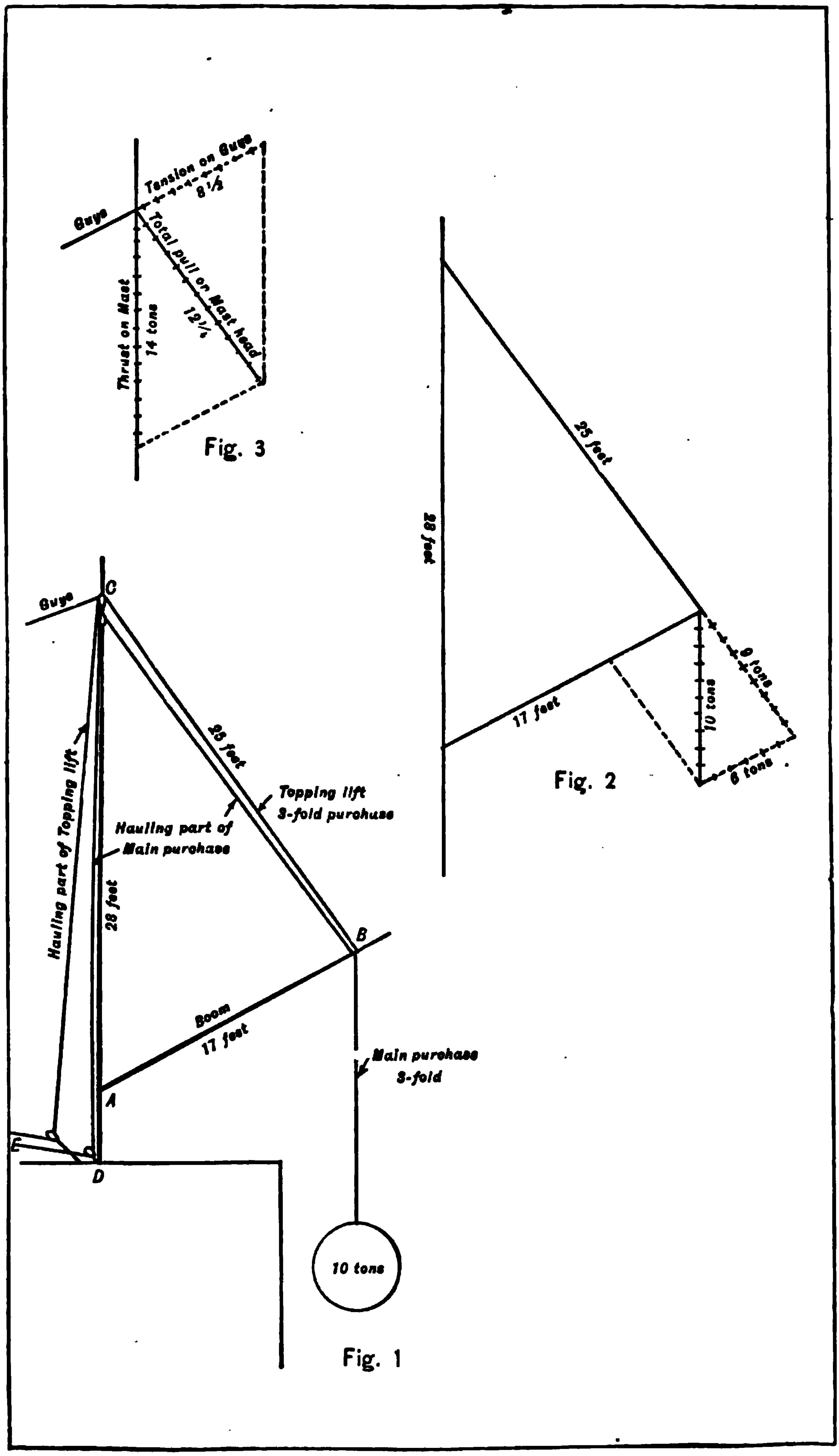
Load on topping-lift due to weight $=9$ tons.

Or thus,

$$\frac{\text{Load on lift}}{\text{Weight}}=\frac{\text{Length of lift}}{\text{Length of mast}}=\frac{25}{28}$$

Load on lift $=9$ tons.

This could be estimated closely by the eye.



HANDLING WEIGHTS BY A DERRICK.

As the boom is to be topped up, we must add the resistance due to friction, in calculating the strength of fall required.

Total resistance on topping-lift including friction,

$$=9+\frac{7}{10}9=16.3 \text{ tons (nearly).}$$

Maximum tension on fall of topping-lift $=\frac{16.3}{6}=2.75$ tons.

Size of fall required for topping-lift $=\sqrt{15\times 2.75}=6\frac{1}{2}$ (nearly).

(c) *To find the tension on the guys.*

The pull on the masthead is the load on the topping-lift (9 tons) plus the tension on the part, BC, of the main purchase fall leading from the boom-end to the masthead.

We have found the tension on the hauling part DE, to be 2.75 tons. The tension on BC is considerably less than this, being reduced by the friction of two intervening sheaves; but for convenience we may neglect this difference, and take 2.75 tons for the tension on BC. This gives, for the pull to be resisted by the guys, $9+2.75=11.75$ tons. The tension on the guys is found from this as in other examples preceding.

Tension on guys $=8\frac{1}{2}$ tons.

(d) To find the thrust on the boom.

This is the resolved component along the line of the boom $=6$ tons.

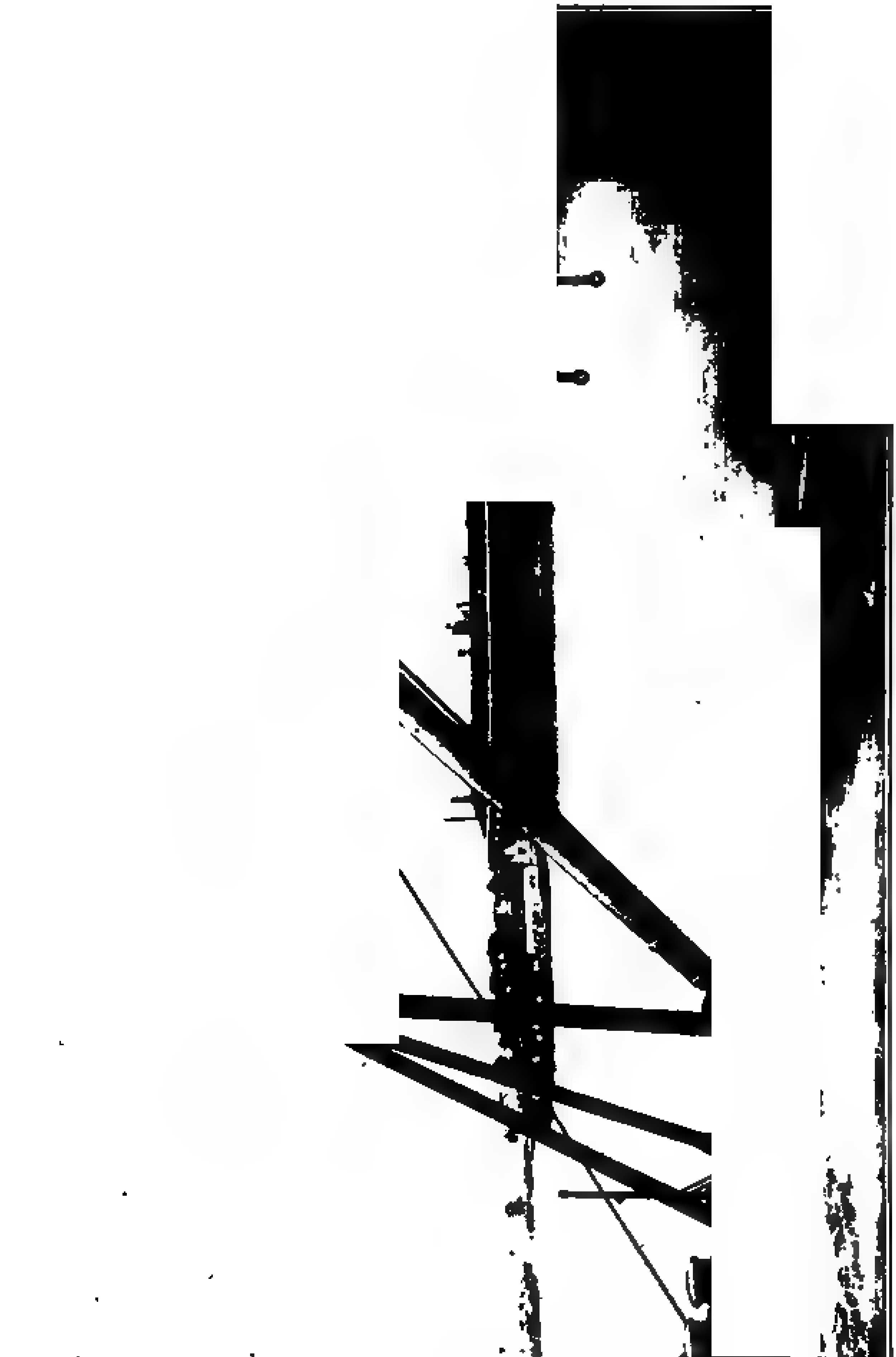
(e) To determine what thrust the boom will safely stand. Diameter of spar 10 inches; length 17 feet.

By Rule 9, §IV, Chap. VI.

$$T=\frac{4R^4}{L^2}=\frac{4\times 5^4}{17^2}=8.6 \text{ tons.}$$

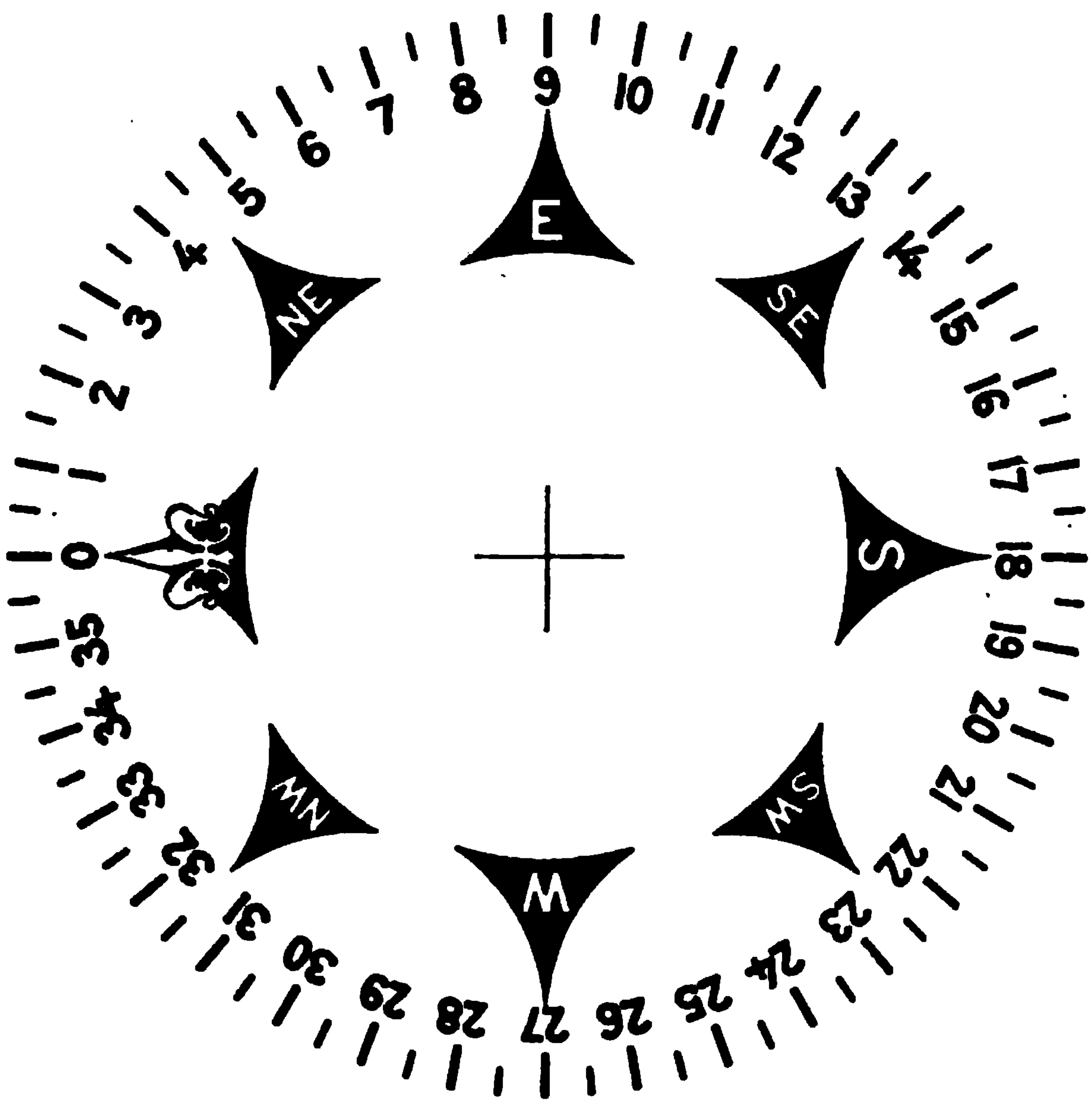
Hence the boom is strong enough to stand this thrust and also the increased thrust (about 20 per cent) which will result from topping up the boom to land the boiler on the deck.

Plate No. 46.

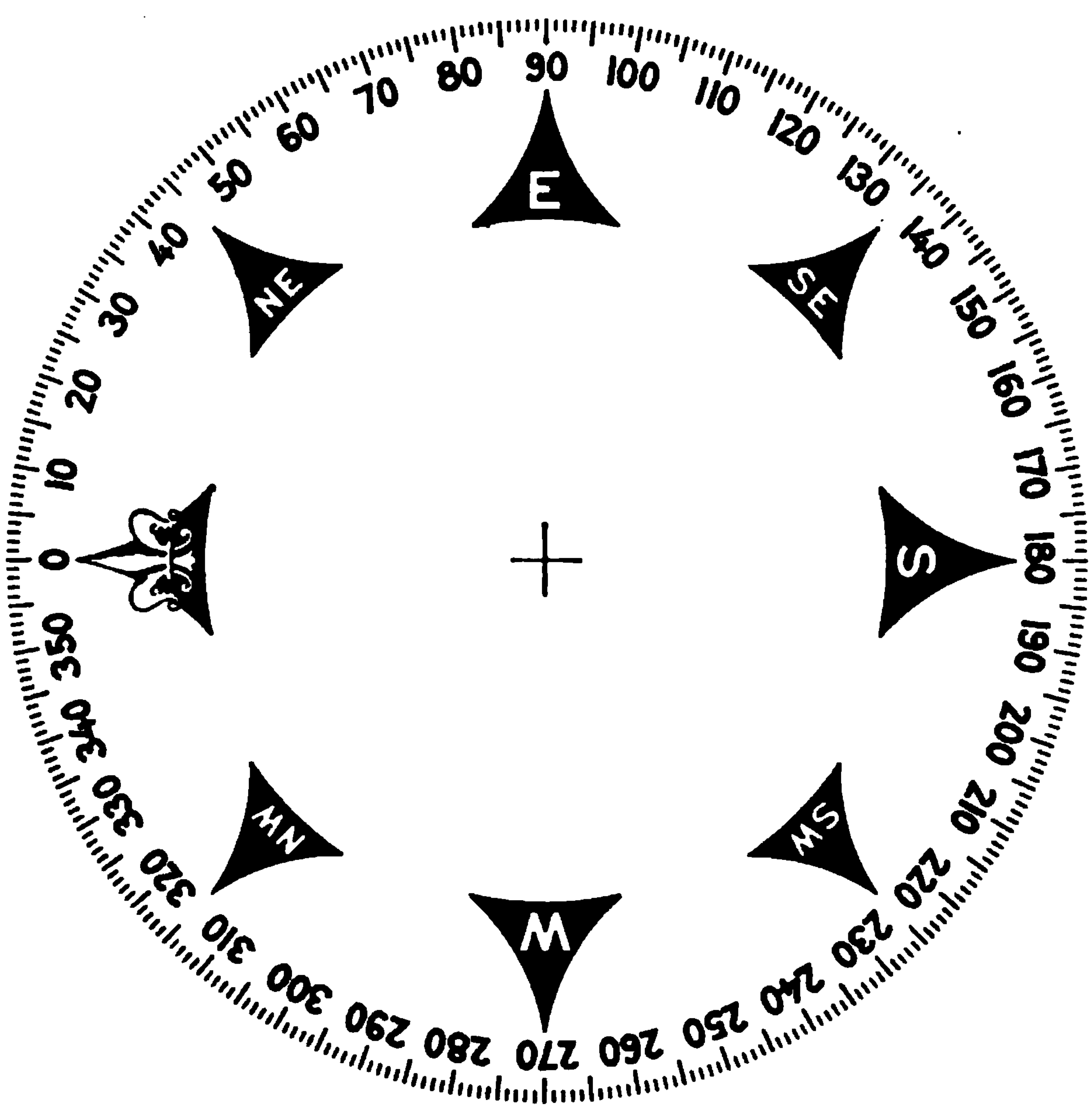


COALING BOOM.

Plate No. 47.



Boat Compass.



Ship Compass.

COMPASS CARDS.

CHAPTER VIII.

THE COMPASS, LOG AND LEAD—SUBMARINE SIGNALS.

§ I. THE MAGNETIC COMPASS.

The essential part of the compass is a magnetic needle which turns freely on a pivot, and which, if unaffected by local disturbing influences, would point due north and south (magnetic). The local influences which necessarily exist on ship-board and which on steel ships are very large, are more or less fully neutralized by the methods used to "compensate" the compass; and the needle does, in general, point approximately to the magnetic poles.

A recent experience in which a ship was stranded because a small piece of iron had been carelessly left near the compass suggests the necessity for a warning on this point. Iron or steel, even in masses as small as a pocketknife, if brought near the compass, may affect it. Helmsmen and quartermasters should understand this.

Stanchions, railings and other metal fittings near a compass should preferably be of bronze or other non-magnetic substance. If made of iron, they should never be absent, while the compass is in use, from the positions occupied when observations for deviation are made.

Attached to the needle and moving with it, is a circular card marked around its circumference with two graduations; one of points, half-points and quarter-points, the other of degrees. (Plate 47 and 48.)

The card with the attached needle (or needles) is floated in a liquid composed of 45 per cent pure alcohol, and 55 per cent distilled water, within a chamber, where it is pivoted upon a jewelled bearing which keeps the card centered and supports a small fraction of its weight. On the inside rim of the card-chamber is a vertical mark known as the "**lubber's point**," which, in installing the compass, is carefully adjusted in the fore-and-aft line of the ship with reference to the center of the card. In steering, this mark is held in coincidence with the point of the card indicating the course to be steered. The lubber's point is the thing that moves. The card is stationary.

The graduation of the card in points and half-points runs as follows, beginning at North:

North.	**South.**
N. ½E.	S. ½W.
N. by E.	S. by W.
N. by E. ½E.	S. by W. ½W.
NNE.	SSW.
NNE. ½E.	SSW. ½W.
NE. by N.	SW. by S.
NE. ½N.	SW. ½S.
NE.	SW.
NE. ½E.	SW. ½W.
NE. by E.	SW. by W.
NE. by E. ½E.	SW. by W. ½W.
ENE.	WSW.
ENE. ½E.	WSW. ½W.
E. by N.	W. by S.
E. ½N.	W. ½S.
East.	**West.**
E. ½S.	W. ½N.
E. by S.	W. by N.
ESE. ½E.	WNW. ½W.
ESE.	WNW.
SE. by E. ½E.	NW. by W. ½W.
SE. by E.	NW. by W.
SE. ½E.	NW. ½W.
SE.	NW.
SE. ½S.	NW. ½N.
SE. by S.	NW. by N.
SSE. ½E.	NNW. ½W.
SSE.	NNW.
S. by E. ½E.	N. by W. ½W.
S. by E.	N. by W.
S. ½E.	N. ½W.
South.	**North.**

NOTE.—For convenience the ¼ points between the ½ points are omitted in the above. They appear on the compass-card and are always given in *Boxing the Compass;* i.e., in enumerating the points and fractional parts of points from North around by way of East, South and West, back to North.

North, South, East and West are called "Cardinal Points"; **Northeast, Southeast, Southwest and Northwest,** "Intercardinal Points."

OLD STYLE COMPASS CARDS.

The delicacy with which steamers can be steered by means of the arrangements now employed for the purpose is leading to the disuse of points and quarter-points for compass work and the custom is becoming general of shaping courses and noting bearings, in degrees. The seemingly trifling error that may be involved in attempting to steer by fractions of a point, while of little consequence to a slow vessel in a short run, may be vital to a steamer making four or five hundred miles a day.

As there are 32 points in the circle, each point evidently represents 11¼° (11° 15′).

On the compass-card which has been in use until very recently, the graduation by *degrees* begins at North and at South and runs 90° to right and left toward East and West. Thus on this card we have, in the North-east quadrant, N. 1° E., N. 2° E., etc., up to N. 90° E.; and in the South-east quadrant, S. 1° E., S. 2° E., etc., up to S. 90° E. **East** may be regarded, therefore, as either N. 90° E., or S. 90° E.

Similarly we have in the North-west quadrant, N. 1° W., N. 2° W., etc., up to N. 90° W.; and in the South-west quadrant, S. 1° W.; S. 2° W., up to S. 90° W., so that **West** may be regarded as either N. 90° W. or S. 90° W.

Thus courses may be designated either in points or in degrees. NE. is N. 45° E.; ESE. is S. 67° 30′ E.; SW. by S. is S. 33° 45′ W.; etc.

Compass Card U. S. Navy.

Plate **47** shows a new form of compass-card which has lately been adopted in the United States Navy. On this card the degrees run *in a continuous graduation* (to the right) completely around the circle from North to North again, through 360°. With this card, bearings and courses may be designated simply by the number of degrees from North. Thus North-east is "45°"; East is "90°"; South-west is "225°"; North-west is "315°"; etc.

§ II. THE GYROSCOPIC COMPASS.[1]

This type of compass has been developed to a very high degree of accuracy and reliability during the last few years and is now extensively used on war vessels in the United States and in Europe. It is also in use on a few of the large Trans-Atlantic Liners. This compass is entirely independent of magnetism and is therefore not subject to the disturbing magnetic influences always

[1] By Lieut.-Commander Charles T. Owens, U. S. Navy.

found on board ship which often render the magnetic compass unreliable and for which careful compensation is required. It points to the true geographical pole instead of to the magnetic pole, thus eliminating the variation of the compass. As its directive force is very much stronger than that of the magnetic compass, errors due to lag and sluggishness of the compass are also eliminated.

A gyroscope, if so mounted as to have freedom of motion about three rectangular axes, will maintain its axis of rotation fixed in space, unless it is acted upon by some externally impressed angular force. Since it maintains its axis of rotation fixed in space, this axis will have an apparent motion relatively to the earth's surface, which is evidenced by its continually changing its inclination to the horizontal plane. To illustrate this, let it be supposed that the gyroscope is spinning with its axis pointing directly at a star in the horizon whose bearing is due East. It will soon be observed that the axis is following the star in its apparent diurnal movement. If in the Northern hemisphere it will gradually rise and turn toward the South, reaching its highest elevation in six hours when the star is on the meridian, and returning to the horizontal again in twelve hours when the star is bearing due West. That extremity of the axis pointing to the star will continue to follow the latter as it falls below the horizon, reaching its greatest depression in 18 hours and returning to the horizontal in 24 hours as the star again appears in the horizon. During this 24 hours the earth has completed one revolution on its axis while the star and the gyroscope have remained fixed in space. Had the axis of the gyroscope initially pointed to the celestial North pole (the North Star, approximately) its inclination to the horizontal would have remained unchanged throughout the 24 hours.

In the gyro-compass the spinning wheel or gyroscope is mounted in a casing on ball-bearings and is made to rotate at the highest practicable speed by an electrical alternating current induction motor. It is so suspended as to have freedom of motion about three rectangular axes, and would if not acted upon by any externally impressed angular force, have motion relatively to the earth's surface exactly as described above. By means of a weight applied to the casing carrying the gyroscope, however, gravity is made to impress an external angular force as soon as the axis of the gyroscope begins to tilt above the horizontal and the result is that the axis of the gyroscope is drawn toward the

meridian and is held pointing steadily to the North. This is in accordance with the following law discovered by Foucalt: "Any revolving mass such as a spinning wheel, tends to swing around so as to bring its axis of rotation parallel to the axis of any externally applied angular force and in such a relation that the direction of rotation is the same as the direction of the said applied or impressed force."

Combined with the gyroscope casing is a compass card graduated in a similar manner to the card of a magnetic compass, having its North-South line parallel to the axis of rotation of the gyroscope, and the entire structure is suspended from gimbal rings mounted in a binnacle or stand.

The mechanical devices employed to render the compass accurate and reliable not only on shore but on a moving ship where it is subject to the motions of rolling, pitching and yawing, are much too complicated to be described here. It may be stated, however, that the readings of the compass card must be corrected for certain errors due to the fact that on a moving ship the gyroscope is acted upon not by the simple Easterly motion of the earth alone but by the resultant of the earth's motion combined with the ship's and the axis will therefore be deflected from the true North by an amount depending upon the course and speed of the ship and the latitude. The correction may be made by mechanical correction devices attached to the compass which move the lubber's line by the proper amount to make the course as read off from the card, the true course, or it may be taken from tables or charts especially prepared for the purpose.

From the above description it will be seen that whenever the axis of rotation of the gyroscope in the gyro-compass is not pointing North and South, the rotation of the earth will cause an apparent tilting of the axis with relation to the horizontal plane, thus bringing gravity into play to swing the compass in to the meridian. In reality it is the horizontal plane of the earth which is constantly changing its inclination in space and it is this which gives the compass its directive force. It follows therefore that at either of the earth's poles where the horizontal plane remains fixed in space the compass has no directive force and at the equator where the inclination of the horizontal plane is changing at the most rapid rate, the directive force is a maximum. This may be compared to the magnetic compass which has a maximum directive force at the magnetic equator and none at the magnetic poles. In

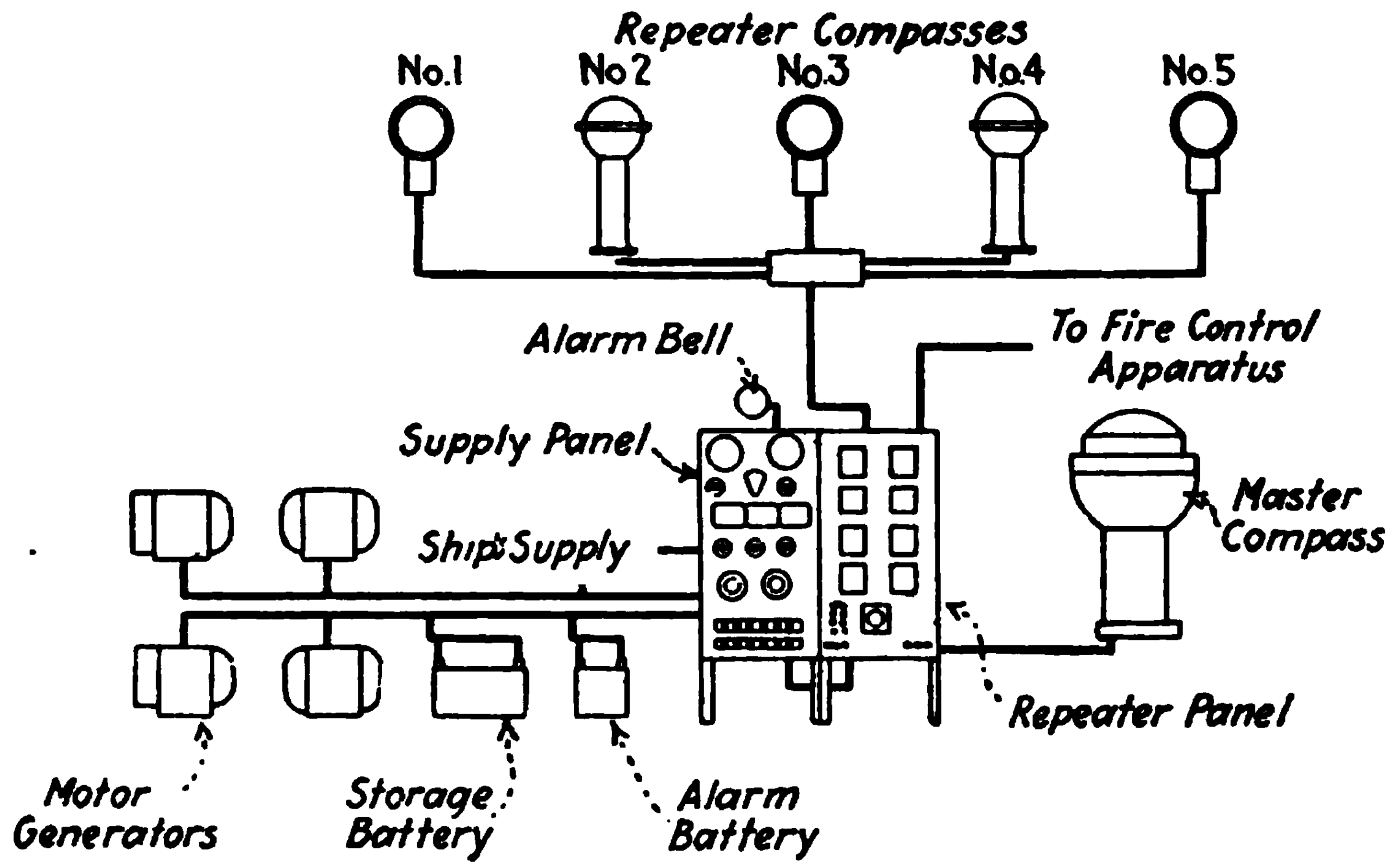


Fig. 1

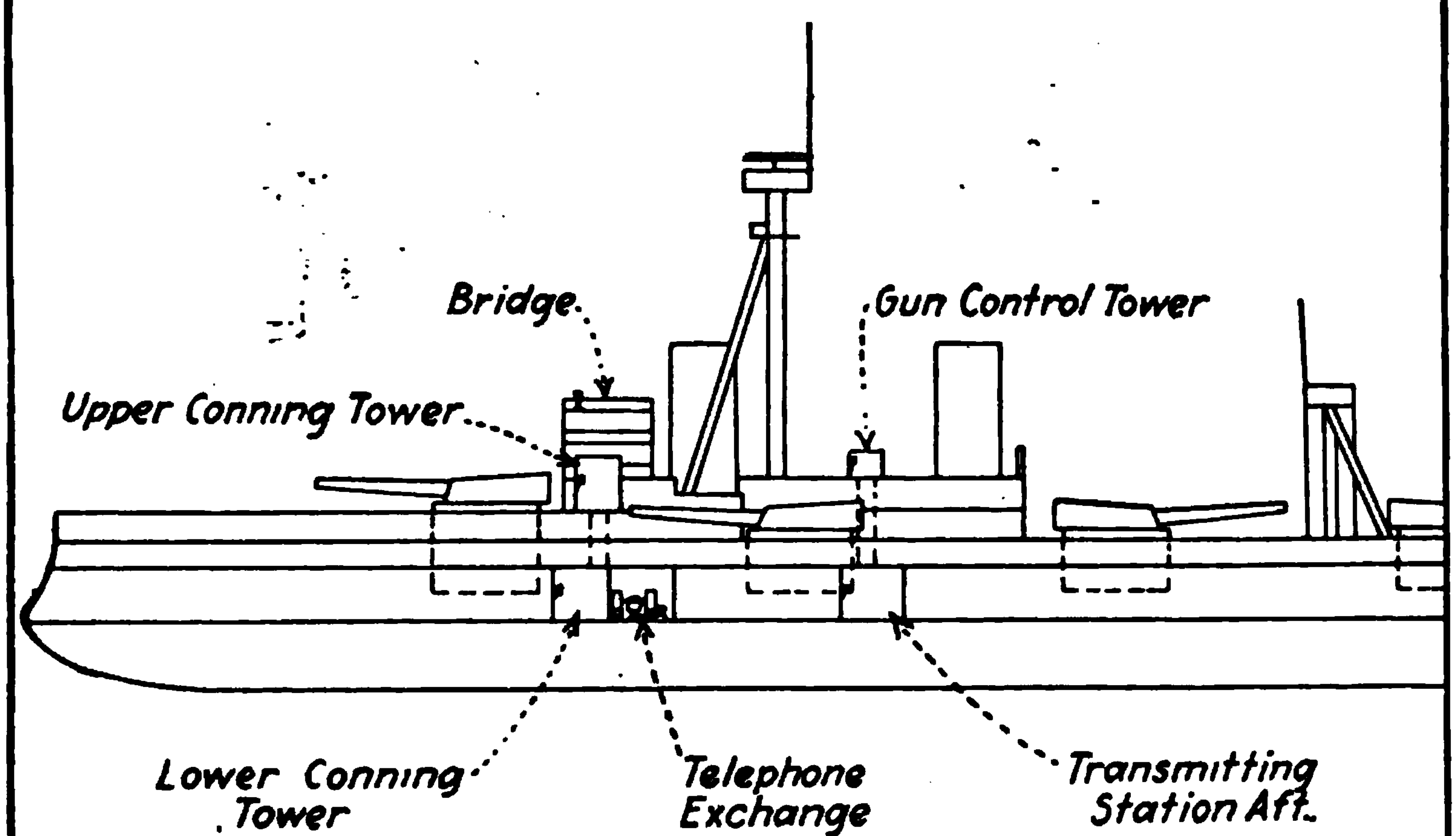


Fig. 2

GYRO COMPASS—BATTLESHIP EQUIPMENT.

Plate No. 50.

MASTER GYRO COMPASS, REPEATERS AND SWITCHBOARD.

this connection it is interesting to note that the directive force of the gyro-compass is not only many times greater than that of the magnetic compass at the equator but that on going into higher latitudes the directive force of the magnetic compass tends to decrease much more rapidly than that of the gyro-compass.

The Gyro-Compass equipment of a Battleship consists of a *Master Compass* which is usually installed in a protected position below decks, with controlling switch-board, motor-generators, storage battery and repeater-panel for controlling any number of "repeaters" in different parts of the ship:—Conning tower, Bridge (Steering and Pelorus stands), Steering Engine Room, Fire Control Station, etc., all of these repeaters being electrically connected with the Master Gyro and governed by it. The repeaters resemble in external appearance the ordinary magnetic compass and are so designed that they can be shipped in gimbal rings in place of peloruses for use in taking bearings, or rigidly mounted in front of the helmsman for steering purposes. Plates 49 and 50.

While the gyro-compass has practically replaced the magnetic compass wherever it is installed, it is considered necessary to retain the magnetic compass as a check on the gyro and for use in case of casualty to the latter. It is doubtful if the magnetic compass will ever be dispensed with on any ship.

The gyro compass is a highly specialized mechanism which requires intelligent care for successful operation. Instructions for the care and operation should be rigorously carried out. The navigator should frequently inspect the switch panels, generating sets, and master, to insure that the parts are kept free from dust, rust and verdigris. It is a matter for emphasis that untrained personnel should not tamper with the equipment or attempt alterations; and in case that any but minor repairs are necessary, the services of a gyro compass officer from the fleet or Navy Yard should be called upon.

The compass should be started up at least four hours before sailing as the normal settling period of the gyro compass is three hours. Latitude dials should be set and the compass checked before getting under way. While under way changes of speed and latitude should be communicated to the gyro electrician on watch in order to keep the dial settings for the speed and latitude so that at all times the gyro bearings and courses may agree with true bearings and courses.

The Pelorus or Dumb Compass is a circle marked with the graduation of a compass-card, but without a needle, which may be mounted at any part of the ship for use in taking bearings. A zero-line on this instrument is permanently fixed parallel to

the fore-and-aft line of the ship, and a movable sighting bar admits of measuring at any instant the angle between the heading of the ship and an object sighted upon. This instrument may therefore be used for determining the compass-bearing of any object, the ship's-head by compass and the bearing of the object by the pelorus being noted simultaneously. Bearings may thus be taken of objects which cannot be seen from the compass. A convenient form of the pelorus is one in which the graduated circle can be turned inside of the fixed rim which carries the zero-mark, while the sighting-bar turns independently of both. In this form of the instrument, the point of the movable circle corresponding with the compass course of the ship is made to coincide with the zero-mark, so that the compass bearings of objects sighted upon are read off directly, *provided that the ship is exactly on her course at the instant of making the observation.* If it is necessary to make the observation while she is not on the course for which the pelorus is set, the difference must be noted and applied to the bearing observed.

Suppose the pelorus is set for a course *West,* and an observation taken when the ship is actually heading to the *left* of this course:—say W½S. The bearing given by the pelorus must be corrected by ½ point applied to the left (like westerly deviation). If, the pelorus being set as before for West, the ship actually heads to the *right* of this course—say W½N—the correction must be applied to the right, like easterly deviation.

The accuracy of the adjustment of the zero-line in the keel-line of the ship may be determined by setting the circle to the compass course and taking simultaneous bearings with the compass and pelorus of a distant object. If an error is found to exist, it may be noted and applied as a permanent correction to all observations taken with the instrument; or the adjustment may be corrected.

Evidently, if the pelorus is set for the *magnetic* instead of the compass course, the bearings observed with it will be *magnetic.*

PLATE **51** shows a convenient type of pelorus which is used to a considerable extent in both the Navy and the Merchant Service. One of its distinctive features is that the dial and the sight-vanes can be clamped together at a known bearing of an object so that when directed at the object it immediately gives the ship's heading.

A gyro-compass repeater may be shipped in the pelorus stand, where it becomes itself a pelorus.

Bearings. The bearing (or direction) of an object from the

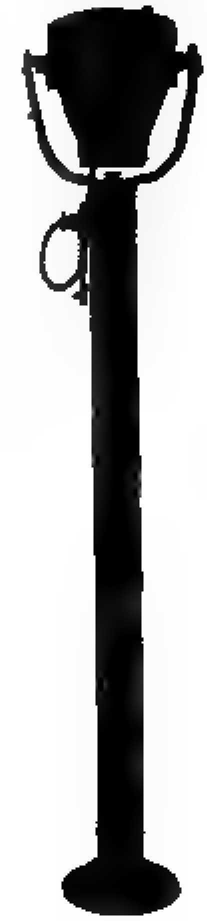


Fig. 1. Pelorus.

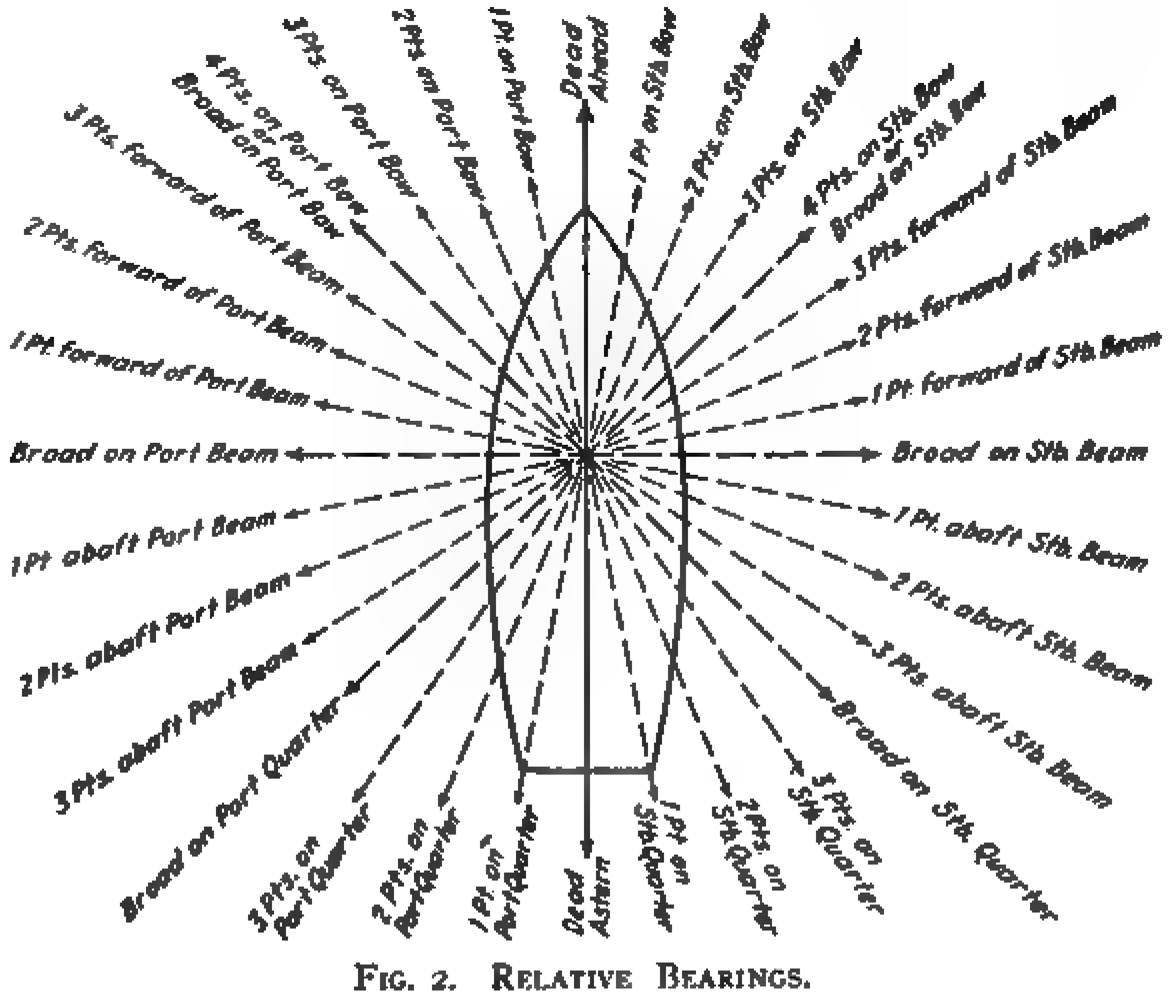


Fig. 2. Relative Bearings.

ship may be stated either as a compass direction or as a direction relatively to the line of the ship's keel.

A *compass* bearing is expressed like a course steered. A lighthouse, for example, bears NE (old compass) or 45° (new compass). A *relative* bearing is expressed in points and fractions of a point from the ship's *head, beam,* or *stern,* as illustrated in Plate 51.

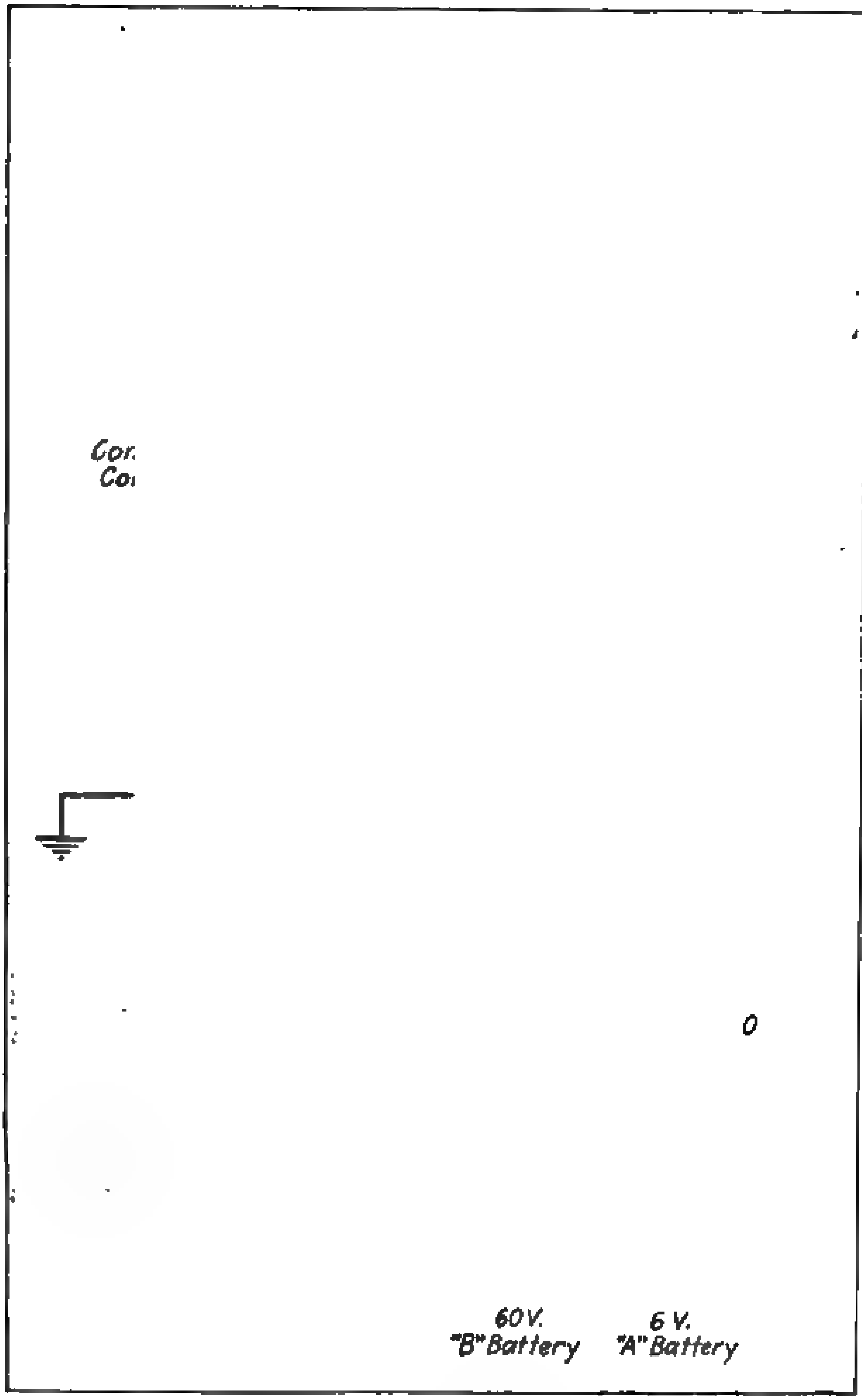
§ III. THE RADIO COMPASS

The Radio Compass is an instrument of recent development for receiving radio signals and at the same time determining the direction from which the signals are coming;—in other words, determining the *bearing of the origin* of the radio waves. It consists essentially of a coil of wire for receiving the signals, the wire being wrapped around a frame as shown in Plates 52 and 53 and the ends of the coil connected with suitable apparatus for making the signals audible through the usual head-phones. The coil is mounted on a vertical axis above a horizontal circle graduated in degrees, and a pointer connected with the coil indicates the angle at which the coil stands with reference to the zero line of the circle, which is, or may be, fixed at true north. Radio signals impinging upon the receiving coil become audible in the head-phones of the operator, the intensity of the sound varying with the position of the coil relatively to the direction from which the signals are coming. If the coil stands at right angles to this direction (Fig. 1, Plate 53), no sound is heard. If it stands directly in this line the sound is at its maximum intensity.

Thus the operator can determine the line from which the signals are coming, either by *maximum intensity* of the sound, indicating that the wires of the coil are pointing toward the origin of the signals or by the *total disappearance* of the sound, indicating that the coil is standing at right angles to the desired direction. It is found in practice that more accurate determination of direction is possible by the *disappearance* of sound than by its *maximum intensity;* and the pointer is accordingly placed on the *side* of the coil, as shown in Fig. 1.

Radio Compass Stations have been established by many of the important maritime Powers and the positions of these stations are communicated to all ships having radio equipment.

A ship wishing to know its bearing from a Radio Compass Station calls the station, and asks "What is my bearing"? The



RADIO COMPASS.

bearing having been received is plotted like any other line of bearing. If bearings are received from two or more stations, the result is a *cut* which fixes the ship's position. In a more complete application of the system, two stations which have determined the bearings of a ship report these to a Central Station, which plots the lines, establishes the *cut* and gives the ship its *position* instead of its bearings. (Plate 53.)

§ IV. THE MEASUREMENT OF SPEED.

The speed of a ship may be measured by a Patent Log, of which there are many types, or by the revolutions of the propellers. It may also, of course, be determined by running over a measured course or between bearings of charted points on shore. Whatever method is used, due allowance must be made for currents, and the distinction recognized between speed through the water and speed over the ground. The speed indicated by a log is speed through the water. That determined by any one of the other methods mentioned is speed over the ground.

Patent Logs. With few exceptions, these consist of a "rotator," in principle like the propeller of a ship, which is towed through the water and thus made to rotate with a velocity varying directly with the speed, and a series of gears and dials to which the motion of the rotator is transmitted by a cord, the dials registering the distance corresponding to the revolutions of the rotator. In a "taffrail" log, the registering mechanism is on the taffrail and a long line is used between it and the rotator; in a "harpoon" log, the registering mechanism is towed astern with the rotator and must be hauled in for reading. As the record of a patent log is one of distance and not of speed, we must, to find the speed, note the run for a given length of time.

Plate 54 shows several types of patent logs in common use. By a simple "make-and-break" attachment, the record of the rotator can be transmitted electrically to a dial in the chart-house or elsewhere.

A patent log should be given the same care that is accorded to other mechanical devices from which accurate working is expected. It should be oiled daily when in use and kept in a dry place at other times. Logs of the harpoon type should be washed in fresh water before being stowed away.

When a log is first put in service, care should be taken to determine accurately its percentage of errors. This will be found

Plate No. 54.

PATENT LOGS.

to vary considerably with the speed, a log which runs correctly at ten knots, being, perhaps, materially in error at fifteen.

The only way to determine the error satisfactorily is by runs of some length between known points where the effects of wind and tide are small. As some effect must always be expected from such causes, a number of runs will be needed to get a reliable error; and for every run that is made, a record should be kept of the comparison between the distance made good by chart and that recorded by the log, a distinguishing number or letter being assigned to each rotator and each register so that their identity may be preserved throughout the record.

If the record shows also the draft of the ship, the revolutions of the engines and the details of wind and sea, it may be of great value in checking the calibration of the ship's screws as hereinafter described.

The length of log-line used has much to do with the working of the log. The proper length to use under ordinary circumstances is that issued with the log by its makers; but it is found that a greater length is needed for a high than for a low speed. Logs are commonly accompanied by instruments for changing the pitch of the rotator-blades to correct an error in running, but unless the error is very great it is better to leave it and apply the correction found from observation.

A disadvantage of logs which depend upon a towed rotator is that the rotator is often fouled by refuse from the ship, or by sea-weed, which vitiates the record transmitted to the recorder, and makes it necessary to haul in and clear the rotator, thus losing the record for an appreciable period. It is principally because of this inconvenience that rotator logs are falling into disuse in spite of their many advantages when used at moderate (cruising) speeds.

The revolutions of the screws afford a very convenient indication of the speed of the ship but are subject to certain corrections, nearly all of which are matters of estimate rather than of exact determination. As a starting point, the revolutions are calibrated with reference to speed under standard conditions,—draft and trim normal, the bottom clean, and weather moderate. Under these conditions curves are constructed for several speeds by running over a measured course, runs being made in both directions to eliminate the effect of wind and current. It is desir-

able that these runs be repeated with varying conditions of draft but this is not always practicable.

For ideal results, runs should also be made with varying conditions of trim and fouling of bottom; but data of this character can be gradually accumulated as experience with the ship progresses. Advantage should be taken of opportunities, such as are constantly arising, for checking the calibration on runs between light-houses and other fixed and charted points, always keeping in mind the possible existence of a current, and noting always the estimated conditions of draft, trim, and bottom.

If the length of time out of dock were an approximately accurate measure of the degree of fouling, the condition of the bottom would always be approximately known, but this is very far from being the case and this element in the problem must be estimated from what is known of the facts. The fouling will be greater in the tropics than in temperate waters; much greater in salt water than in fresh; much greater for time spent at anchor than for time under way. A foul bottom tends to clean itself in steaming at high speed. A ship badly fouled at sea, lying for a long time in fresh water, rids itself of barnacles but may take on grass.

The result of what precedes is that the navigator who relies upon revolutions for his dead-reckoning must apply to his standard calibration curve a correction which at any given time is an *estimate* of the percentage of speed lost or gained by the conditions which he knows to have existed since the last docking of the ship; taking account also of the temporary draft and trim, as well as of the direction and condition of wind and sea. It is the great advantage of a good patent log, carefully calibrated for various speeds, that it gives the actual distance run (through the water) with no other correction than that based upon its own error.

Vessels like the Trans-Atlantic liners, which make long trips at high speed (and almost unvarying speed) depend, for their dead-reckoning, upon revolutions alone, relying largely upon soundings for checking their positions when approaching land in a fog. So, too, vessels like the Sound and River steamers of the United States, when running in a fog, depend upon revloutions and rarely come to grief.

But it must be remembered that the masters of these vessels spend years in running over the same routes, with the same ships,

under conditions which vary but little from trip to trip; so that they are able to estimate the factors involved in their navigation with almost perfect confidence.

It must be understood that all the methods which have been described above give the speed **through the water,** not over the ground. To get the speed over the ground, use is sometimes made of a "ground-log" consisting of a moderately heavy lead on the end of a log-line. The lead is thrown over and allowed to sink to the bottom, after which the line is paid out and the time noted, exactly as in the case of the chip-log, care being taken not to drag the lead. This method not only gives the speed over the bottom but shows the direction of the set. Its availability is confined to rather shallow water and to very low speeds, but it is often very valuable, especially in confined waters, in a fog, where the force and direction of the current may be of vital importance and where the speed is necessarily low.

To stop the ship dead in the water and put over a ground-log may give information of the greatest possible value as to the direction and force of the current.

The records given by the logs which have been described above are records of **distance** and not of **speed.** From the distance recorded in any given interval of time we can find the average speed during that interval, but not the actual speed at any instant.

There are on the market several types of patent logs which depend on the *pressure* of the water resulting from the speed of the ship. Such a log is the *Nicholson,* which aims to give both the instantaneous speed and the distance run. It gives also, in connection with a clock, a continuous graphic record of speed.

In principle, this log consists of a vertical tube passing through the bottom of the ship and projecting several inches below. The lower end of the tube is closed, but an opening in the forward side gives free entrance to the water, which accordingly rises, when the ship is at rest, to a level corresponding with the level of the water outside; that is to say, with the momentary water-line of the ship. As the ship moves ahead, the pressure due to her speed is communicated to the column of water in the pipe, where it is added to the pressure due to the "head" of water outside; with the result that the column rises in the tube to a height which becomes a measure of the speed. Inside the tube is a float, connected through suitable gearing with a pointer which indicates

the fall and rise of the float and the corresponding speed. A counter-weight at the other end of the chain balances the float.

This instrument was at one time very generally used in ships of the United States Navy but it has not proved satisfactory in practice and has been removed from most of the ships. It is described here because the principle upon which it is based is unquestionably sound and one which may ultimately find a more successful application.

The Forbes Log, which has for some years been used in the British Navy, has recently been supplied to several battleships of the United States Navy. It resembles the Nicholson log in that it uses a tube projecting through the bottom of the ship, with mechanism running from this tube to the chart house and actuating a recorder there. It differs from the Nicholson in that the record of the speed depends not upon the pressure of the water but upon the velocity of a screw rotator carried below the bottom of the ship in the lower end of the projecting tube. The end of the tube is open on both the forward and after sides so that the water has a free course through the orifice in which the rotator is carried.

§ V. SOUNDING.

THE LEAD.

The ordinary method of getting the depth of water is by means of a "lead" and line. A hand-lead, used for moderate depths, may weigh anywhere from 7 to 14 lbs. and a good leadsman will get soundings in depths up to 5 fathoms with the ship going 8 knots. If reliable soundings are wanted in depths greater than this, the speed must be reduced or the sounding-machine used.

The old style of marking the lead-line was as follows:

At 2	fathoms,	with 2 strips of leather.	
" 3	"	" 3 " " "	
" 5	"	" a white rag.	
" 7	"	" a red rag.	
" 10	"	" a piece of leather with a hole in it.	
" 13	"	the same as at 3 fathoms.	
" 15	"	" " 5 "	
" 17	"	" " 7 "	
" 20	"	with 2 knots.	
" 25	"	" 1 knot.	

The above are called the "marks." The intervening depths are "deeps."

The old style of reporting the soundings was:

"By the mark, three!"
"By the deep, four!"
"A quarter less, three!"
"And a quarter, four!"
etc., etc.

This method of marking the lead-line and of reporting soundings is antiquated and should be obsolete. A lead-line should have a mark for every fathom and half-fathom up to 10 fathoms; and for a considerable range—covering the depths that are critical for the ship using it—it should be marked in feet. Thus, if a ship draws 20 feet of water, there should be a mark at every foot between 20 and 30. The soundings should be reported by the leadsman, sharply and clearly, in fathoms and fractions for depths exceeding, say 6 fathoms, and in feet for depths below this.

The lead-line should be of some material that will neither stretch nor shrink excessively as it is alternately wet and dried. An ideal material for this purpose has yet to be proposed. It may be that wire-rope of sufficient flexibility will some time be put on the market.

The lead-lines (wet) should be carefully measured and remarked, each time they are to be used.

As the mark at the water's edge cannot be seen at night, some navigators like to mark their lines in such a way that the depth is indicated by the mark *in the leadsman's hand* when the line is up and down. This calls for a length of stray line equal to the drift from the water's edge to the leadsman's waist; this distance being laid off on the line before beginning to measure for the marks.

Sounding Machines. There are several types of sounding machines on the market, all depending upon the same principle and differing but little in details. The original machine of this type was invented many years ago by the great Scotch scientist, Lord Kelvin (then Sir William Thomson), and all later machines are based upon the principle which he first applied,—the principle of determining the depth of water by the pressure of the water at the depth in question, this pressure being regisered on the inside of a glass tube open at one end and closed at the other. If such

a tube, with the closed end up, is lowered in the water, the pressure of the water, acting upon the air with which the tube is filled, compresses the air and forces the water up into the tube to a height which depends upon the pressure and therefore upon the depth. This is the first part of the problem involved. The second part is to find a method of automatically registering the maximum height to which the water has risen in the tube.

The tubes issued by the maunfacturers for use with the Kelvin Machine are coated on the inside with chloride of silver, a substance which changes color on contact with salt-water. Thus in taking a sounding the lower part of the tube, up to a point depending upon the depth reached, changes color, leaving a line of sharp demarkation at the point to which the water has risen inside the tube. The height of this mark, measured by a special scale provided with the machine, becomes the measure of the maximum depth to which the tube has sunk.

For the *Tanner-Blish* machine, which is very generally used by American ships and especially by the United States Navy, the glass sounding tubes are *ground* on the inside so that they show clear glass when wet, this being a peculiarity of ground glass. If such a tube is perfectly dry in the beginning, it will, after sounding, show clear glass up to the point to which the water has risen, with a sharp line of demarkation between this part and the dry (and clouded) part above. The upper end of the tube is closed by a water-tight cap which can be removed after each sounding to admit of drying the tube quickly, after which the tube is again ready for use. This results in a considerable economy in the expenditure of tubes.

The Kelvin and Tanner-Blish tubes may be used interchangeably.

Whatever type of tube is used, great care should be taken to keep the closed end upward after sounding. If it is capsized, a little water may run into the upper end of the tube and spoil the record.

Plate 55 shows the Kelvin and Tanner-Blish Machines. Fig. 2 shows mechanical details of the Kelvin. The corresponding details of the Tanner-Blish, while differing somewhat from those here shown, are similar in principle. In each machine we have a drum carrying a coil of light but very strong wire rope about 200 fathoms in length. The drum is controlled by a brake by which the rate at which the wire runs out can be regulated. Fig.

SOUNDING MACHINES.

5 shows the machine in use. The tube is carried in a metal cylinder for protection and a heavy sinker of lead or iron insures its rapid sinking.

All being in readiness as shown in the figure, the brake is released and the wire runs out, trailing far astern if the ship is moving at high speed.

A dial shows the length of wire out at any given instant and the speed of running out is regulated as desired by manipulation of the brake. If the sinker finds bottom, the wire slacks suddenly and the brake must be applied immediately to prevent kinking of the wire. As a further insurance against kinking, it is well to use the brass finger-pin supplied with the machine, keeping a light pressure on the wire as it runs out, and standing by to press down quickly upon the bight of the wire as it slacks.

The wire should always be stopped while an ample length remains on the drum.

The length of wire that has run out would be a measure of the depth if the speed of the ship and the friction of the machine were constant. In practice, a quartermaster who is accustomed to his machine and uses his brake uniformly can make a fair estimate of the depth without waiting to reel in and read the tube. Such an estimate may often give an instant warning of danger. In some types of the Kelvin Machine an effort has been made to provide for constant friction on the brake, and a table is issued with the machine giving the depth for different speeds corresponding to the length of wire out as indicated by the dial. This is valuable, but not sufficiently reliable to replace a careful reading of the tube as soon as this is available.

For large ships motors are fitted for reeling in the wire.

It is convenient to mount the sounding machine on the bridge, with an outrigger and a fair-lead block to carry the wire clear of the ship's side. (Plate 55, Fig. 5.) With such an arrangement everything is under the eye of the officer of the watch.

§ VI. SUBMARINE SIGNALS.

This is a system for transmitting sound signals through the water, and receiving them by special instruments on shipboard, the receiving arrangement being of such a nature as to admit of determining, at least approximately, the direction from which the sound is received. It is in fact a system of "Direction Finding"

applied to *sound* closely resembling, in principle and in operation, the Radio Compass as applied to radio waves.

In its original and simplest form,—the form which admits of both sending and receiving from a fixed station but of receiving alone from a moving station,—the system is as follows:

A **bell**, immersed as far as is convenient below water, is so placed as to mark a danger or a point of importance in piloting, and is automatically sounded at certain intervals with a characteristic signal which fixes its identity. The sound of the bell is transmitted through the water, and experiments show that it can be heard *without instruments* at a distance of several miles, by a listener whose ear is held against the inner skin of a ship below the water-line. It seems to be established that even with this crude arrangement for receiving, sound-signals transmitted through the water are superior in range and reliability to those transmitted through the air. With the special apparatus shown in Plate **56** for receiving the sound and transmitting it, magnified, to the ear, the range of audibility is from 10 to 30 miles, depending upon conditions;—that is to say, upon the speed of the ship and the bearing of the bell. High speed is to some extent unfavorable, doubtless because the wash of the water along the side interferes with the sound. The bearing of the bell with reference to the ship's head determines the angle at which the sound-waves strike the receiver, the result being that a signal on the beam can be heard much farther than one which is forward of or abaft the beam.

If the submarine did nothing more than to announce *with certainty* the proximity of the danger which it marks, it would be a very valuable aid to navigation. But it does much more than this. It fixes the *direction* of the danger within narrow limits; and in those waters—common enough on irregular coasts—where the zones of two or more signals intersect (or will intersect when the use of the system becomes more general), the position of the ship may be plotted with considerable accuracy by the crossing of the lines of bearing, exactly as in the case of visible bearings, though not with the same degree of accuracy.

The receiving apparatus (Plate **56**) consists of a small iron tank attached to the side of the ship, wholly on the inside, and filled with salt water. In this tank is a delicate receiver which takes up the sounds as they come to it through the water and

Plate No. 56.

Transmitter Case in Hold of Ship.
(Connected Electrically with Receiving Telephones in Pilot-House.)

Direction Indicator and Receiving Telephone.

SUBMARINE SOUND SIGNALLING APPARATUS.
Old Type.

transmits them through an electric circuit to a telephone in the pilot house or on the bridge.

A switch admits of throwing in either the starboard or the port receiver. If it is desired to listen to both sides, the receivers are thrown in alternately, by a movement of the switch. If the sound is heard more clearly in the starboard than in the port receiver it is known that the signal lies to starboard. If it is equally clear in both receivers, the signal is directly ahead (or astern). If, as the ship swings, the sound grows fainter in one transmitter and clearer in the other, the signal is drawing toward that beam from which it is heard more clearly. When it is at a maximum it is approximately abeam.

A signal which is decidedly on one side of the ship will hardly ever be heard through the opposite receiver; but when only a little on one bow, it can usually be heard in the receiver on the opposite bow. Thus, as has been explained, a signal which is nearly ahead and not very far distant may be heard through both receivers.

If the signal is more distant, the sound will be lost, even in the near receiver, as the ship's head swings up to it, and will not be picked up on the other side until perhaps a point or more on the bow. In this case, its bearing may be taken as approximately midway between the heading on which it is lost and that on which it is again picked up.

A ship picking up a signal through the starboard receiver knows that the bell lies to starboard and in all probability forward of the beam. The sound may be expected to grow clearer until the bell is abeam, and then to grow fainter as it draws abaft.

If its approximate bearing is wanted before it comes abeam, the course may be changed toward it and the speed reduced if necessary. The bearing is then determined as has been explained above.

While it is not claimed in the present development of the system that the signals can be heard beyond about 15 miles, there are many cases recorded in which they have been heard at more than twice this distance. Vessels carrying their receivers well below the water-line can hear to a greater distance than others. A vessel at rest hears farther than one that is moving. And certain configurations of the bottom seem to have the effect of gathering up and concentrating the waves of sound and transmitting them to a distance, like a megaphone.

It is evident that the receivers of a ship can pick up other sounds than those from a bell and that they may thus be useful, for example, in giving notice of the proximity of another ship whose propellers are turning over. The noise of the propellers might in many cases be heard much farther than a fog-whistle. When the arrangements described below for *transmitting* from vessels underway have been fully perfected, vessels in a fog will be able to communicate at much greater distances than at present, and there seems no reason why there should not be devised some plan—perhaps by revolving the receiving instrument—for determining the direction from which the signals come, without the inconvenience and delay incident to such changes of course as have been described in connection with piloting.

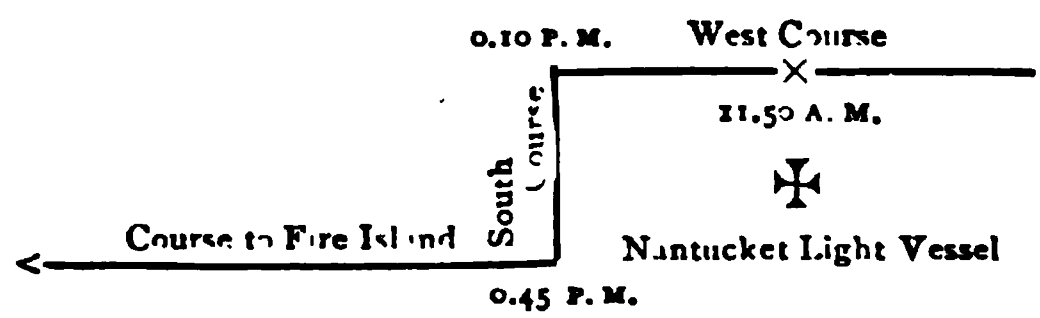
The following is an interesting example of a practical application of the system:

Approaching Nantucket light vessel on a west course in a dense fog with a light S. S. E. breeze and smooth sea on May 5, 1906, we heard the submarine signal very slightly on our port side in a distance say about 4 to 6 miles. When the sound ceased at 0.10 p. m., I put the vessel on a South course and heard the signal then again till 0.45 p. m. I was then sure that I had the light vessel to the eastward and put my course direct for Fire Island light vessel. During all the time we never heard a single sound of the Nantucket light vessel's steam whistle.

Yours very truly,

(Signed) CAPT. R. SAURMANN,

S. S. Amerika.



With the above apparatus, as has been explained, a ship can receive signals but cannot send them. The Submarine Signal Company has long been engaged in an effort to develop a system which should make sending possible from a moving ship. The Fessenden Oscillator, recently perfected, promises a solution of the problem. This is both a sending and a receiving instrument. For sending it greatly surpasses the submarine bell both in power and in speed of operation. It can be readily mounted on shipboard and produces signals equally effective whether the vessel is in movement or at rest, gives a signal of full power for any desired time (as contrasted with the bell, the vibrations of which

SWITCHBOARD SUBMARINE SIGNAL SYSTEM.

lose their power rapidly), and can start or stop almost instantaneously.

As a receiving instrument it is quite as effective as the microphone used in the earlier submarine signalling apparatus.

It is unnecessary to dwell upon the advantages connected with a system like this which makes it possible for a ship to interchange signals with another ship or with a shore station, and this without regard to weather conditions, "zones of silence" or "interference."

Like the microphone tanks of the earlier signalling apparatus, the box containing the oscillator is bolted to the inner skin of the ship well below the water-line, but whereas the tanks containing the microphones of the earlier system were filled with water, the box containing the oscillator is filled with air, and, as it is of the first importance that this air should be dry, it is given a pressure of twenty-five pounds to the square inch before the box is sealed up.

The oscillator is attached to the skin of the ship in such a way that its diaphragm actually constitutes a part of the ship's plating, a circular hole being cut in the side to admit of this.

The action of the oscillator is in many respects similar to that of a telephone receiver. The diaphragm is vibrated, as in the telephone, by rapid variations in the polarity of an electro-magnet. But as the diaphragm is enormously larger and thicker than that of the telephone, its operation calls for the use of powerful electric currents. The standard type takes a direct current of seven amperes through the main magnetic coil and an alternating current of eleven amperes through the core. The instrument is operated from a switchboard shown on Plate 57. Sending is done by an ordinary telegraph key; receiving, by telephone receivers.

The method of locating the direction of a signal received is exactly the same as with the earlier microphone system which has been fully described.

There is every reason to believe that the oscillator system will before many years be required as a part of the safety outfit of every seagoing vessel.

CHAPTER IX.

BOATS.

§ I.

Boats designed to be carried on shipboard are subject to many conditions which define their characteristics within narrow limits, especially as regards their size and weight. These limits are determined, first of all, by the specific purposes for which the boats are to be used; and next by the facilities available for stowing and handling them.

The boats of a merchant vessel are intended almost exclusively for saving life in circumstances of emergency, when they must be handled by a small number of men and usually under conditions of more than ordinary difficulty. It is therefore as important for them to be light and handy as to be roomy and seaworthy. The boats of men-of-war are used for a great variety of purposes, of which life saving is by no means the first, and in design are necessarily a compromise between conflicting demands.

Merchant Steamers, and especially passenger steamers (including transports), are required by law to carry a number of boats proportioned to the maximum total personnel which they are authorized to carry. Moreover, the law prescribes with much detail the character of the boats and the facilities which shall be provided for their stowage and handling. These facilities are directed almost exclusively toward getting the passengers safely away from the ship in case of necessity and ensuring their safety so long as they may be obliged to remain in the boats. Thus the question of *lowering* the boats and getting them clear of the ship receives vastly more attention than that of hoisting them. In the matter of stowage, also, questions of convenience must be sacrificed wherever necessary for quick and safe handling in an emergency.

Conditions are entirely different on men-of-war, where everything else gives way to military efficiency. Here the boats are stowed and handled as best they may be after every possible

facility has been provided for pointing and firing the guns. Moreover, since the boats of a man-of-war, instead of being reserved for some special emergency, are designed and used for scores of purposes connected with the everyday life of the ship, the question of *hoisting* is quite as important as that of *lowering*.

Construction of Boats. (Plates 58 and 59.)

Boats are made of both wood and metal and by a great variety of systems. In *wood,* three general types of construction are common: *Carvel, Clinker* and *Diagonal.* (Plate 58.)

In *Carvel* building (Fig. 1), the planks lie alongside each other without overlapping, the seams being calked. Where the build is too light to admit of calking, a narrow batten or riband is run along the seams inside, the calking being in this case limited to the garboard seams and the butting ends of the planks.

Where heavy boats are built on this system, a second layer of planking is sometimes used inside the frames.

In *Clinker* building (Fig. 2), the planks overlap at their edges like the clapboarding on a house, and are fastened to each other as well as to the frames. As the planks thus support each other, this system has greater strength for a given weight than Carvel building and the frames can be placed farther apart. On the other hand, the planks are liable to split along the line of fastenings, and repairs called for by this or other injuries to the boat are made with some difficulty because of the necessity of removing several planks to repair one. The seams are not calked, the swelling of the planks causing them to bind tightly upon each other. To keep them tight, the boat should be put in the water frequently, or, if that is impracticable, well wetted with a hose from time to time.

In *Diagonal* building (Fig. 3), the planks run diagonally at an angle of 45° from the keel to the gunwale and two thicknesses of planking are used, at right angles to each other. No frames are needed. This is a strong system of building, but necessarily a heavy one. As a rule it is used only for large boats carrying heavy weights.

The Carvel and Diagonal Systems are sometimes combined, two layers of planking being used, one Carvel laid, the other Diagonal.

The *parts of a boat* are shown on Plate 59.

Metallic Boats. *Metallic* boats are preferable to wooden ones when they are to be carried in such positions that they are of

Fig. 1. Carvel.

Fig. 2. Clinker.

Fig. 3. Diagonal.

Plate No. 59.

PARTS OF A BOAT.

necessity exposed to excessive heat and moisture and when they are not to be often used. They are especially desirable for ships which are to spend much time in the tropics. If subject to the sort of treatment that the boats of a man-of-war necessarily receive they would quickly be battered out of shape, and sooner or later punctured, when the problem of repair on shipboard would become a difficult one.

The plating of metallic boats is of sheet steel, galvanized. The keel, stem and stern-post are sometimes also of steel but more commonly of wood. Especial precautions should be taken in the design to make all parts accessible for inspection, drying, cleaning and painting, to prevent damage from rusting and galvanic action, the danger of such damage being the principal objection urged against this kind of boat. Another objection is, of course, *that unless buoyancy is provided by air tanks* or other artificial means, the boat will sink immediately if it fills or capsizes, whereas a wooden boat under these conditions will not only float itself but provide a limited degree of support for the crew.

Buoyancy of Boats. As a rule, boats carried on shipboard, whether of wood or metal, are fitted with air-tanks for reserve buoyancy. Such tanks are of wood, copper, or galvanized sheet steel. In the *United States Coast Guard Service,* which probably has as much experience with boats as any other organization in the world, metal has been entirely discarded for wood, the tanks being built-in and made of two layers of planking, tongued and grooved, with canvas and white lead between the layers.

The position of the air-tanks, especially as regards height, is an important consideration. If carried high, they tend to keep the boat from capsizing and help to right it if it is capsized; but if above the thwarts, they reduce the space available for passengers and interfere with the handling of the oars. If carried low, they keep down the center of gravity of the boat, not only by their own weight but by lowering the seating space for passengers, but this advantage is offset by the fact that they actually increase the difficulty of righting the boat if it is capsized. The general practice is, nevertheless, to place them below the thwarts (Plate 60), but it will be explained later how and to what extent the arrangement is modified in what are specifically designed as *Self-righting* boats.

Classification of Boats.

Note.—Regulations as to ship's boats are established for United States merchant vessels by the Steamboat Inspection Service under the Department of Commerce and for British vessels by the Board of Trade.

Ship's boats are classified as follows:

Class I. Rigid-Sided Life boats. Plate 60.
" II. Collapsible-Sided Life boats. Plate 64.
" III. Open Boats without Air-tank Buoyancy.

Classes I and II are sub-divided according to variations of construction into I A, I B, I C and II A, II B and II C, and are required to have air-tank buoyancy proportioned to the number of passengers they are designed to carry.

Class I A, Plate 60, may be regarded as the standard life boat of the merchant service. It may be either metal or wood; and if of wood, of either Carvel or Clinker construction.

The required buoyancy may be given either by tanks running along the side or by compartments at bow and stern, or by a combination of these systems.

The law requires that a wooden boat of Class I A must have an internal buoyancy by air tanks of at least 10 per cent. of the cubic capacity of the boat, and that a metal boat shall have sufficient air-tank buoyancy to make its total equal to that of a corresponding wooden boat.

The number of persons that may be carried in a I A boat is found theoretically by allowing 10 cubic feet of space for each person. The practical way of determining this is to decide upon a safe minimum of freeboard for the service required, and then, the boat being in the water, to load to this line with men distributed as they would be distributed in actual service. Nine inches is a fair allowance of freeboard for boats up to 30 feet in length and twelve inches for larger boats.

Self-Baling Boats. (Plate 61, Figs. 3, 4, 5.) In a self-baling boat, a water-tight deck runs throughout the length of the boat slightly above the load water-line. The space below this is thus converted into a water-tight compartment or a series of such compartments. Extending from the deck down through the bottom of the boat are several water-tight trunks, open at top and bottom, through which any water which accumulates on the deck is carried off. The trunks are in effect neither more nor less than *scuppers,* or freeing ports. Evidently they cannot take

FIG.1
Boats, Chocks, Davits, Lashings

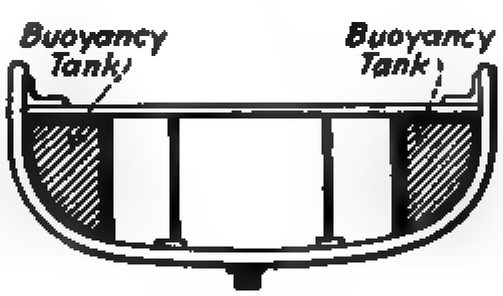


FIG.2
Box Buoyancy Air-Tank

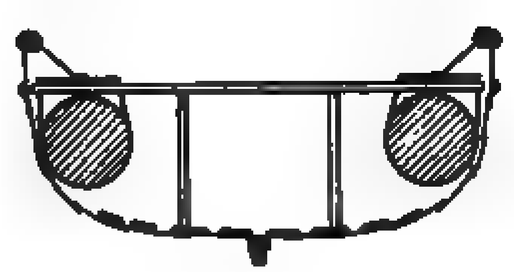


FIG.3
Cylindrical Buoyancy Air-Tank

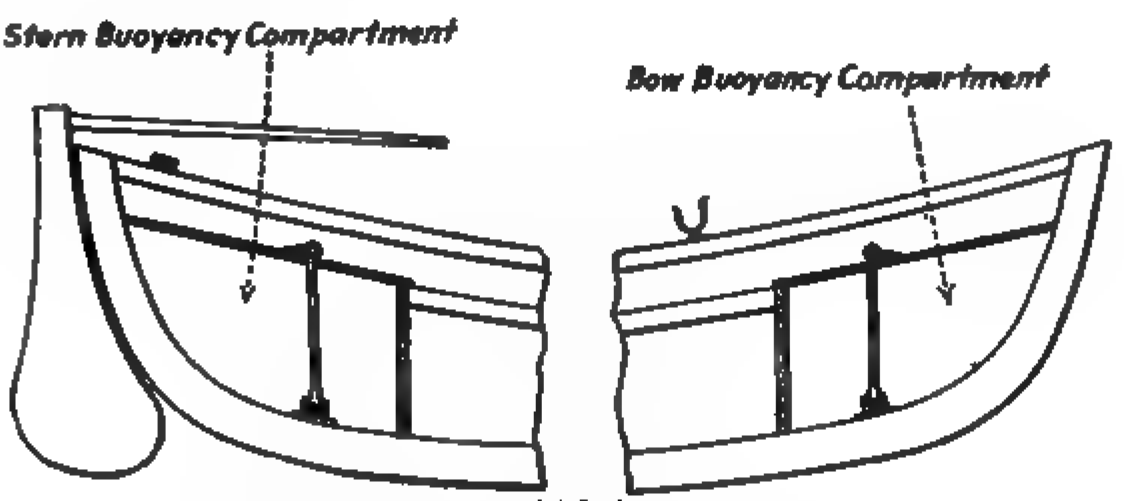


FIG.4
Buoyancy Air Tank Bow and Stern

STANDARD SHIP'S LIFE BOAT (Class I—A).

Plate No. 61.

LIFE BOATS, U. S. COAST GUARD.

care of any water which may enter the compartments below the deck from leaks in the side or bottom of the boat. Such water is pumped out by hand-pumps and if discharged on to the deck, flows off through the trunks like water from a breaking sea.

Self-Righting Boats. (Plate 62.) It is evident, as already explained, that if the buoyancy of a boat can be carried very high there will result a tendency for the boat to right itself if it is capsized, and that this tendency will be increased if the keel is made as heavy as practicable. Self-righting boats are accordingly built of such a shape as to admit of carrying the bow and stern air-tanks very high, and are fitted with a heavy keel of iron or lead.

The self-baling and self-righting features are sometimes combined, but only in large boats. (Plate 62, Figs. 4, 5, 6, 7.)

United States Coast Guard Boats.

Plates 61 and 62 show a very interesting and instructive group of boats, representing the standard types which have been developed, after many years of experiment, by the United States Coast Guard Service As has been already stated, all air-tanks in these boats are of wood; two layers of planking being used, with canvas and white lead between the layers. The boats themselves are also of wood.

Surf Boat. (Plate 61, Fig. 1.) Coast and Ship Type.

Length 26 ft. Weight 2,100 lbs. For oars and sails.

Neither self-righting nor self-baling. Air tanks bow and stern.

This is the so-called "Monomoy" whale boat which has long been used as a surf-boat in the Cape Cod region, one of the wildest parts of the Atlantic Coast. It is light and handy enough to be transported along the beach on a carriage and launched through the surf. Fig. 2 Plate 67 shows this boat fitted for running in through a surf, with a drogue (drag) to prevent broaching to.

In addition to its use as a surf boat, this type is carried by vessels of the Coast Guard for use as a life boat (hanging from davits) and for general service such as running lines, communicating with other ships, etc.

Self-Baling Surf Boat. (Plate 61, Figs 3, 4, 5.)

Coast and Ship Type.

Length 25 ft. 6 in. Weight 2,200 lbs. For oars and sails.

Self-baling features: Water-tight deck above load water-line.

Plate No. 62.

LIFE BOATS, U. S. COAST GUARD.

Water-tight compartments below deck. Freeing trunks.

Other features: Water-tight compartments at bow and stern, above deck. Tank near midship section which may be filled with water-ballast by a hand-pump.

This type is used for the same purpose as that of Fig. 1 and like the type of Fig. 1 can be transported on a carriage and launched through the surf. It is sometimes issued to vessels for use as a life boat and is not too heavy to be carried at davits.

Motor Surf Boat. Self-baling. (Plate 62, Figs. 1, 2, 3.) Coast Type.

Length 26 feet. Weight 3,300 lbs. Gasoline engine, oars and sails.

Self-baling and other features as in preceding type. Engine compartment water-tight.

NOTE.—Several boats of this type have been issued to ships of the Navy for test as to their suitability for use as life-boats, replacing the whale boat which has long been the standard Navy Life Boat.

The motor surf boat, if adopted, will probably be carried on the upper deck to be handled by a crane, special arrangements being made for getting it into the water quickly.

Motor Life Boat. (Plate 62, Figs. 4, 5, 6.) Self-Baling and Self-Righting. Coast Type.

Length 36 feet. Weight 14,300 lbs.

Self-baling features same as the other types.

Self-righting features: High bow and stern air-tanks. High engine compartment, water-tight. Cast-iron keel, 1,800 lbs.

This type is too heavy to be launched from an exposed or shallow beach. It is designed for use in localities where sheltered inlets are available as bases from which to operate along a considerable stretch of coast. This is an extremely capable boat and when once launched will go through practically any surf and live in any sea.

Shipping Board Boats. The standard boat of the United States Shipping Board and Emergency Fleet Corporation is a 26-foot metallic boat, with sharp bow and stern, with cylindrical air-tanks of galvanized steel running fore and aft under the thwarts. The keel and stem and stern posts are also of steel.

Steward "Deadrise" Boat. (Plate 63.) This is a metallic boat manufactured by the Steward Davit and Equipment Corporation. The flat floor of this design makes it possible to carry the air-tanks lower than in a boat with a round bilge and admits

STEWARD LIFE BOATS, DAVITS AND LOWERING DRUM.

of lowering the thwarts and thus the center of gravity of the loaded boat. The elimination of many of the curves which are involved in the conventional full-bilge design reduces the number of plates and therefore the number of seams and rivets; and with these, the danger of leakage. Experience appears to justify the further and more important claim that the design has advantages in the matter of seaworthiness.

The author is in receipt of the following statement from the Third Mate of the Steamer "Liberty Glo" which was cut in two by a floating mine off the coast of Holland, in December, 1919. The boat mentioned was the Steward boat of Plate 63.

> "The boat in which I left the ship proved to be a remarkable sea-boat. We went through breakers that looked miles high, rushing along at express speed, combers covering our boat with a smother of white water, yet at no time did we ever broach. When we had landed, the people of Schiermonnikoog would hardly believe that we had come in through the breakers from the North Sea in an open boat"

Plate 64 shows the **Lundin** decked life boat, with collapsible sides, capable of carrying 60 passengers with ample reserve buoyancy. The boat is decked throughout its length and fitted with trunks for self-baling. It will be seen that the collapsible feature of the bulwarks adds greatly to the compactness of stowage. The hinged weather boards fold down upon the deck when not needed, but can be quickly raised when the boat is to be used, and lock securely into their places. The space below the deck is divided into water-tight compartments which are in reality air-tanks placed in the very bottom of the boat. This type of boat, in which the buoyancy is secured by a water-tight subdivision of the hull of the boat, and not by the addition of air-tanks, is called the **Pontoon** type.

It is claimed that the characteristic spoon-shaped bow and stern of the Lundin boat add much to its seaworthiness.

Life Rafts. Plate 67, Fig. 3, shows an Elliptical **Life Raft** of a type approved by the Steamboat Inspection Service and by the Navy Department. The elliptical cylinder is sometimes a tubular copper air-tank covered with cork and sometimes is of "balsa" wood, a strong wood lighter than cork, which does not become water-logged.

The elliptical body carries a net, which, when passengers are on the raft, sinks to 3½ feet. In the larger sizes, which are capable of supporting 60 men, a wooden platform is attached to the net to give a more comfortable footing. The smallest size weighs

Plate No. 64.

LUNDIN DECKED BOAT.

only 40 pounds, can be launched overboard by one man, and is capable of supporting five persons.

Man-of-War Boats.

The boats carried by Men-of-War of the United States Navy are classified as follows:

Steam Launches ("Steamers").
Motor Boats.
Sailing Launches (with or without motor propulsion).
Barges (flag ships only).
Cutters.
Whale boats.
Dinghies.
Motor Dories (Destroyers and Gunboats).

Steam Launch. (Plate **65**, Fig. 1.) (Technically called merely a "Steamer.") A large and very heavy boat, formerly the standard working boat of the Navy but now used principally for towing. This type is recognized as unnecessarily heavy and more or less out of date. It is gradually being replaced by the Motor Boat described below. The 50-ft. steamer at present carried by Dreadnoughts will not hereafter be issued, the 40-foot steamer being the largest boat of this type to be hereafter constructed.

Motor Boat. (Plate **65**, Fig. 2.) To replace the Steam Launch. A light, roomy, capable boat, well suited for the general work of the ship. In the 50-foot size, weighs 18,000 pounds as against 50,000 pounds for the 50-foot steamer.

Sailing Launch. A large, roomy boat, of good beam, flat floor and rather shallow draft, designed for handling men and stores and fitted to carry one or more light guns. Equipped with spars and sails, which however are seldom used although the name "Sailing Launch" continues in use. In modern practice, boats of this class are usually fitted with motors capable of giving a speed of from six to eight knots. As thus fitted, the *motor launch* is the general utility boat of the ship and is to a great extent taking the place of other types for miscellaneous work in port and at sea. (Plate **65.**)

Barge. Any boat, without reference to its type, assigned to the personal use of a Flag Officer. The barge of the present day

Plate No. 65.

U. S NAVY BOATS.

is usually a fast, comfortable motor boat of appropriately handsome appearance. (Plate 66.)

Gig. Any boat, without reference to its type, assigned to the personal use of a Commanding Officer..

Cutter. Practically a small launch, though of slightly different build from standard launches. Cutters are being replaced by motor launches.

Dinghy. A small, square-stern boat, pulling four oars, used for light work in port.

Whaleboat. A light carvel or clinker built boat, with sharp bow and stern, with a flat floor and considerable sheer, designed to ride over the waves rather than to cut through them. (Plate 66, Fig. 2.) A very handy boat and the standard type of life-boat for the Navy, using the term "life-boat" in the narrow sense of a boat carried at davits, swung out-board, and kept always (at sea) in readiness for immediate lowering to pick up a man overboard. Carried in this way, a light handy boat is very convenient, not only for life saving but for use in any emergency calling for quick action. There are, however, serious objections on a fighting ship to carrying boats on davits; and in view of the facilities now available for handling boats when stowed in-board, there is a growing belief that all boats, at least in battleships, should be carried on an upper deck. It is probable that davits will soon be banished entirely from fighting ships, life-boats being carried in-board like other boats, with special arrangements for getting them into the water quickly.

Motor Dory. This boat is sufficiently described by its name. It is the handy boat of destroyers and gunboats, supplementing the motor sailor, but is badly adapted for its manifold duties. Its speed is low, its capacity limited, and the protection from weather inadequate.

Modernization of Navy Boats.

The movement toward modernizing Navy boats is progressing rapidly. The 50-foot steamer is already being replaced by the 50-foot motor boat. The 40-foot steamer, while not officially abolished, will gradually be replaced by the 35-foot motor boat.

The 30-foot steamer now carried by gunboats and small cruisers and the motor dory carried by destroyers and other small craft will be replaced by a 26-foot motor boat especially designed to meet the needs of these vessels.

Plate No. 66.

U. S. NAVY BOATS.

Fig. 1. Navy 26-Foot Motor Life Boat. (Special Type)

Fig. 2. Surf Boat with Drogue, Steering Oar, etc.

Fig. 3. Life Rafts.

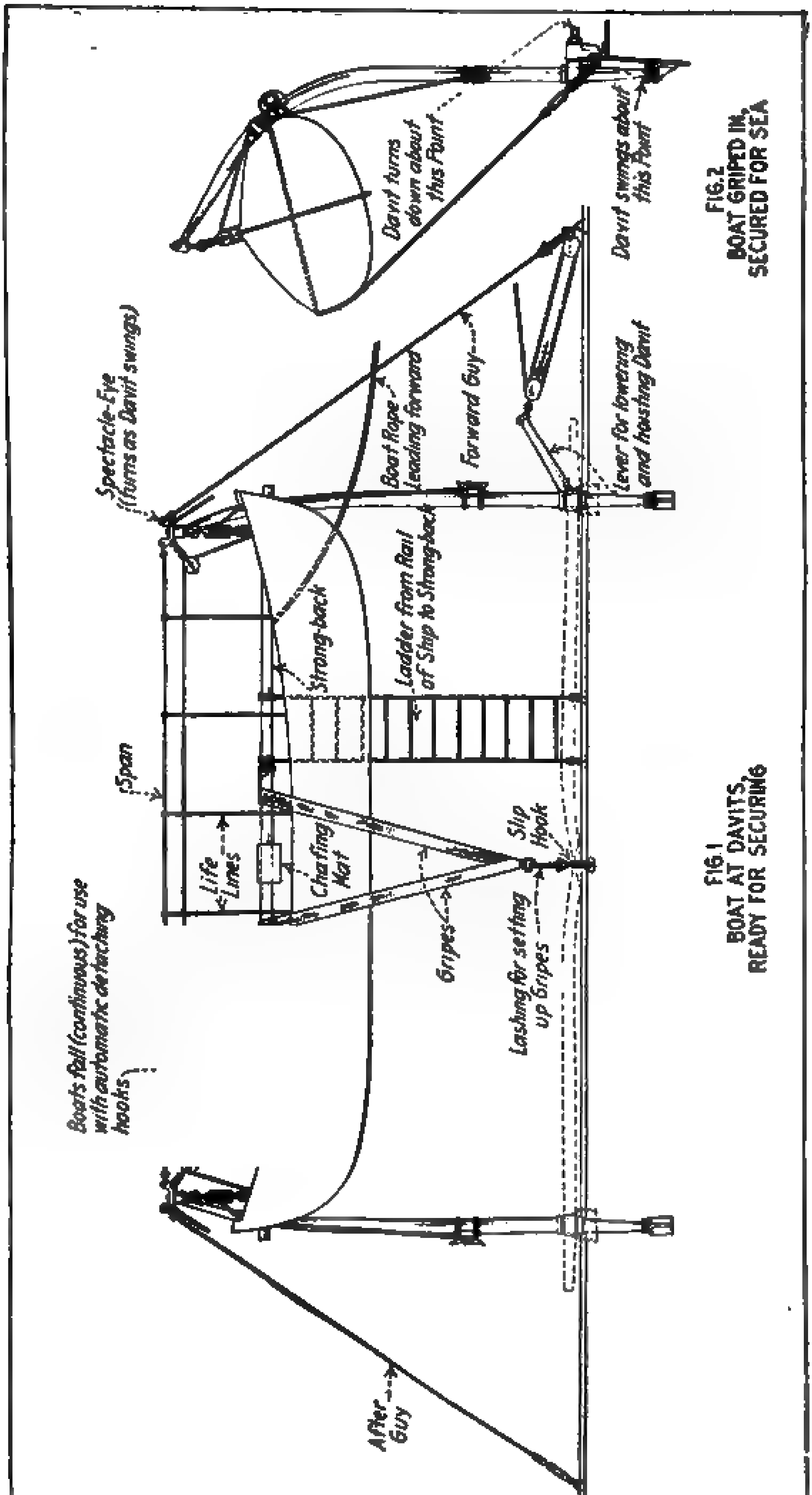
Most important of all, perhaps, the whaleboat which has long been the standard Navy life boat, as above described, is being replaced on large ships by the 26-foot motor life boat shown in Fig. 3, Plate 66, which is to be carried on the upper deck and handled by a boat crane. To make it instantly available, the engine is turned over daily and a man is kept on watch at the boat's crane at all times (at sea).

For smaller vessels, the whaleboat will for the present continue in use as the life boat and it is possible that one or two of this type will be carried on battleships in time of peace for purposes of exercise and recreation.

§ II. THE STOWAGE AND HANDLING OF BOATS.

Merchant Steamers and Transports usually carry their boats in-board under their davits and resting on chocks, with *gripes* (lashings) holding them securely and with canvas covers to protect them from the weather. (Plates 60 and 70.) The tackles are kept hooked and hauled taut, with the falls coiled down either inside or outside the boat, preferably outside. If outside, they are usually coiled in a container of some kind to insure their being always clear for running. A better way is to carry the falls on a *drum*, controlled by a brake, with both falls handled from the same shaft and controlled by the same brake. (Fig. 3, Plate 68.) This makes it possible for one man to lower the boat, keeping it under perfect control, and insures both falls being lowered together. A further advantage of the arrangement, and one which is not always realized, is the *smoothness* with which the boat can be lowered from a drum as contrasted with the jerkiness which often accompanies the lowering of a boat by easing the fall around a cleat. It has been explained (Chapter VII, §2) that the sudden application of a load greatly increases the effect of the stress and may even double it,—a serious matter where the load consists of a life-boat filled with people.

Davits. The old-style curved iron davit (Plate 68) is still in very general use although it is being gradually replaced on passenger steamers and transports by the patent davits to be hereafter described. It rests in a shoe, usually bolted to the side of the ship, and swings on a radius with this shoe as a center. In order that all shall work smoothly, careful attention must be given in the design to the relative positions of the heel of the davit, the head of the davit, and the lifting hook of the boat.



ROUND BAR DAVITS WITH LIFE BOAT.

Also to the distance between the forward and after lifting hooks, and the forward and after davits. The relations of all these features to each other should be such that while the boat is being swung outboard and lowered, the falls shall at all times hang vertically, the ends of the boat being swung, one at a time, in a perfect circle around the heel of the davit.

In all cases where the boats rest in chocks, it is important to avoid the necessity of *lifting* the boats to clear them from the chocks. A common arrangement is one in which chocks are used on the in-board side of the boat only; an iron rod, running along the side of the chock, serving to hold the boat on the outboard side. Plate 70. The *gripes* by which the boat is held down to the chocks are secured by lashings but can be released instantly by tripping a slip-hook such as is always interposed between the deck lashing and the clamp on the gunwale of the boat. It is not difficult to devise a method by which the canvas cover may be secured so that it can be cast adrift quickly.

There are several patented systems of boat control,—two of which are described below—in which all of the above details are covered by methods which have been carefully worked out and found efficient in practice. The important point is that none of the details should be overlooked; for any one of them may be of vital significance in an emergency.

It is of course necessary that the boat-falls should be taut and belayed before the boat is released.

Attention has already been called to the importance of lowering the boat smoothly and to the fact that this can best be done by a drum controlled by a brake. Where no such arrangement is provided, the fall may be led through a snatch-block and taken to a bollard or bitt around which it will run smoothly. The snatch-block must be as near as possible to the heel of the davit, especially if the davits are of the old fashioned type.

Where it is necessary to lower from a cleat, the fall should be belayed in such a way that when it comes to lowering there will be no danger of jamming by reason of one turn riding over another. If, in belaying, the first turn is taken around the shank of the cleat and the later turns in figure-of-eight fashion around the horns, the fall can be eased away in lowering without any turn binding upon any other.

Mechanical Davits. Plates 63 and 68 show two of the best known and most efficient types of mechanical davits,—the

WELIN PATENT DAVIT.

Steward[1] and the *Welin*.[2] While resembling each other in many respects, they differ in the principle utilized for multiplying power; but in both cases the result is that the boat can be cleared away, swung out and lowered by two men, and in a very short time.

Nesting Boats. (Plate **70.**) With certain types of boats and davits it is possible to carry two boats under a single set of davits. This is a great economy of space and where the space gained is utilized to increase the number of boats carried, it is a very desirable feature. But a *given number of boats* will be more accessible when each boat has its own davits.

Many seamen contend that the boats of passenger steamers and transports should be carried hanging at their davits and *swung out,* under all ordinary circumstances, and rigged in only in very bad weather. The fact that all well-organized steamers habitually carry one or two boats in this way is sufficient evidence that it is not impracticable, although the wear and tear upon blocks and falls would doubtless entail considerable expense.

Captain Mills of the Steamship *Westernland* writes to the author in reply to the question whether he considers it practicable to carry the boats of an ocean steamer swung out. "Yes, I have carried this ship's largest boats (548 cubic feet) swung out in several heavy gales and I think they are safer there than in chocks unless the vessel is very low in the water."

Whatever may be thought of the feasibility of this plan in general, there can be no question that all the boats of a passenger steamer should be cleared away and kept ready for lowering at certain times of exceptional danger; as, for example, when running through crowded waters in a fog, or through a danger zone in time of war.

The photograph of the *Olympic* from an air-plane reproduced in Plate **71** shows the practice followed by transports during the World War.

Unless the boats and all their fittings are inspected frequently and thoroughly, there will be trouble when they are wanted. The custom in well-ordered vessels is to overhaul everything when preparing for sea and at regular and frequent intervals afterward; examining and oiling all parts of the disengaging gear and all blocks, swivels, etc. The boats are swung out before starting

[1] Steward Davit and Equipment Corporation, New York.

[2] American Balsa Company, New York.

BOAT CRANE, NESTING OF BOATS AND BOAT CHOCKS

Plate No. 71.

S. S. OLYMPIC FROM AN AIRSHIP.

on a trip, and, if possible, lowered and hoisted to make sure that everything is in good working order. All the fittings and equipments of the boats (see list below) are inspected, water-breakers and bread-tins emptied, cleaned and refilled. Both at sea and in port, wooden boats are wetted frequently to keep the seams tight, but are never allowed to lie for long periods of time with water in them, as this rots the wood and rusts the fittings.

Plugs, if removable, are habitually kept out, but especial care must be taken to insure that they are secured in such a way that they cannot be lost. In modern practice boats are required by law to be fitted with automatic plugs.

Detaching Apparatus (Releasing Gear).

The most important requisite for a detaching apparatus is that it shall be incapable of releasing one end of the boat before the other.

There is much difference of opinion whether the boat should be detached while it is still clear of the water or not until it is "waterborne," but there can be little doubt that the ideal mechanism is one which may be operated under either of these conditions and which, in addition to releasing both ends of the boat simultaneously, makes provision for lowering the boat on an even keel.

The following are the requirements of the United States and British Governments in the matter:

United States Government:

> The life-boats shall be provided with suitable boat disengaging apparatus, so arranged as to allow such boats to be safely launched while such vessels are under speed or otherwise, and so as to allow such disengaging apparatus to be operated by one person disengaging both ends of the boat simultaneously from the tackles by which it may be lowered to the water.

British Board of Trade:

> All disengaging gears must be so arranged as to ensure simultaneous release of both ends of the boat.
>
> The means of effecting release must be placed aft so as to be under the personal control of the coxswain in charge of the boat.
>
> The action should be such that the hook offers no resistance to release should there be a towing strain on the falls.
>
> The hooks must be suitable for instant unhooking by hand.

The gear and mechanism for effecting release must be such and so arranged as to insure the safety of the boat independently of any "safety pins."

No part of the gear taking the weight of the boat is to be made of cast metal.

TESTS:

Boat fully waterborne.

Boat partially waterborne, one end being out of the water.

With the keel of the boat just clear of the water.

Automatic Releasing Hooks.

Plate 72 shows a form of releasing hook used in the United States Navy. The hook is in two parts, hinged one upon the other with a double joint. The outer part, which forms the point of the hook, is weighted, and falls down when free to do so, disengaging itself from the link in the boat. The release can act only when the boat is waterborne, as the weight of the boat at other times holds up the other part of the hook. For hooking on, a lanyard attached to the point of the hook is rove through the link in the boat, and the hook is pulled through with this and held up in place until jammed by the weight of the boat.

To insure detaching both ends together, the falls are rove of a single length of rope "on the bight." This being the case, as soon as one hook is disengaged the slack is communicated to the other fall and the second hook released also.

The following directions are from a pamphlet issued by the manufacturers of the device:

Mode of Reeving the Falls.—"If the boat is always carried outboard two single swivel blocks should be seized to the cranes about six inches from the upper blocks at the davit heads. The falls must be in one piece, and should be passed through the two single blocks until the same amount of rope is on each side of the davits, then go to the lower and upper blocks, the same as if reeving off a set of davit falls ordinarily, with this exception—bring the hauling part of the forward fall through the forward sheave of the upper forward block, and the hauling part of the after fall through the after sheave of the after upper block. A piece of 'ratlin stuff' spliced around a bull's-eye and rove in the bight of the falls between the two single blocks, so that it will play freely between them, will enable one to secure the bight and control it if necessary, and by setting a strain on it hoist the hooks clear of the boat when they are detached. Keeping a strain on the bight and the falls, after the boat is hooked on, takes up whatever slack there is when the sea lifts the boat. By

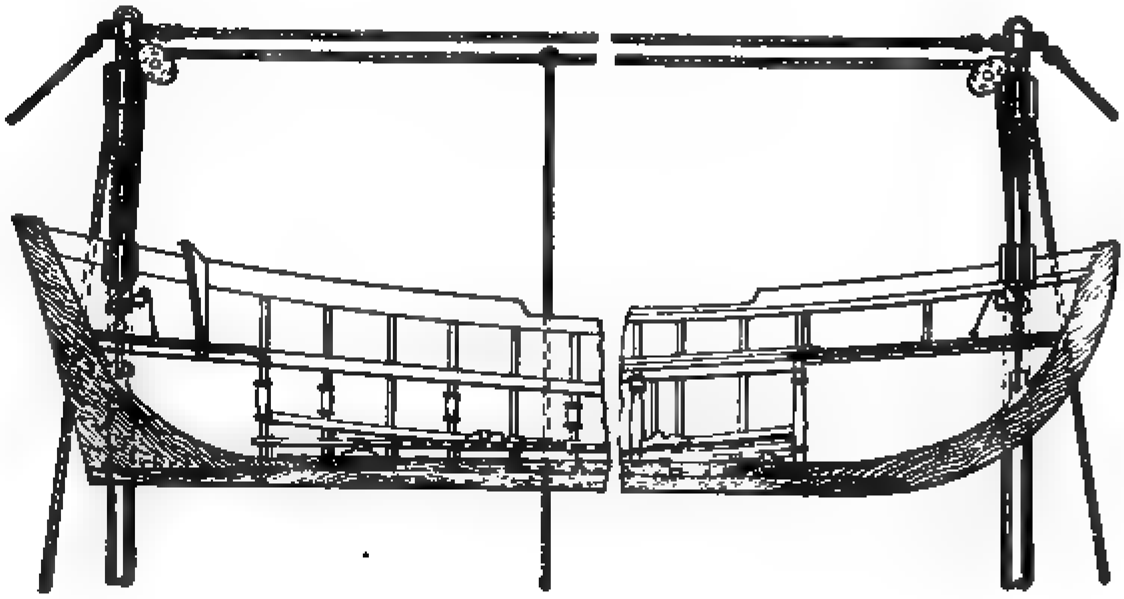


FIG. 1.

FIG. 2.

FIG. 3.

AUTOMATIC RELEASING HOOKS (U. S. NAVY).

stopping the bight between the two single blocks, the falls will act independently of each other and are similar to an ordinary set of davit falls.

"If the boat is carried inboard, the single blocks should be made fast around the necks of the upper blocks with a grommet strap, so as to allow them to swing in and out with the cranes; by doing this the bight of the falls will swing clear of the upper blocks."

The Rottmer Detaching Gear.

Plate 73 illustrates this gear, which is used in the United States Transport service, where it is viewed with much favor.

A rod, made in sections connected by knuckle joints, runs along the keel of the boat, and ends, forward and aft, in a connection, also by a knuckle joint, to an upright locking bolt which carries the detaching hook and mechanism. The upper end of this bolt is a cup, *open on one side.*

The detaching hook is pivoted; and when turned down, engages the cup on the end of the locking bolt.

If this bolt is so turned that the opening in its cupped upper end is in line with the point of the detaching hook, the hook is free to open, and the boat, if hooked on, is at once released.

If, the hook being turned down, we turn the locking bolt in such a way that the wall of the cup holds it from swinging clear, the hook is closed, and the boat may be hooked on.

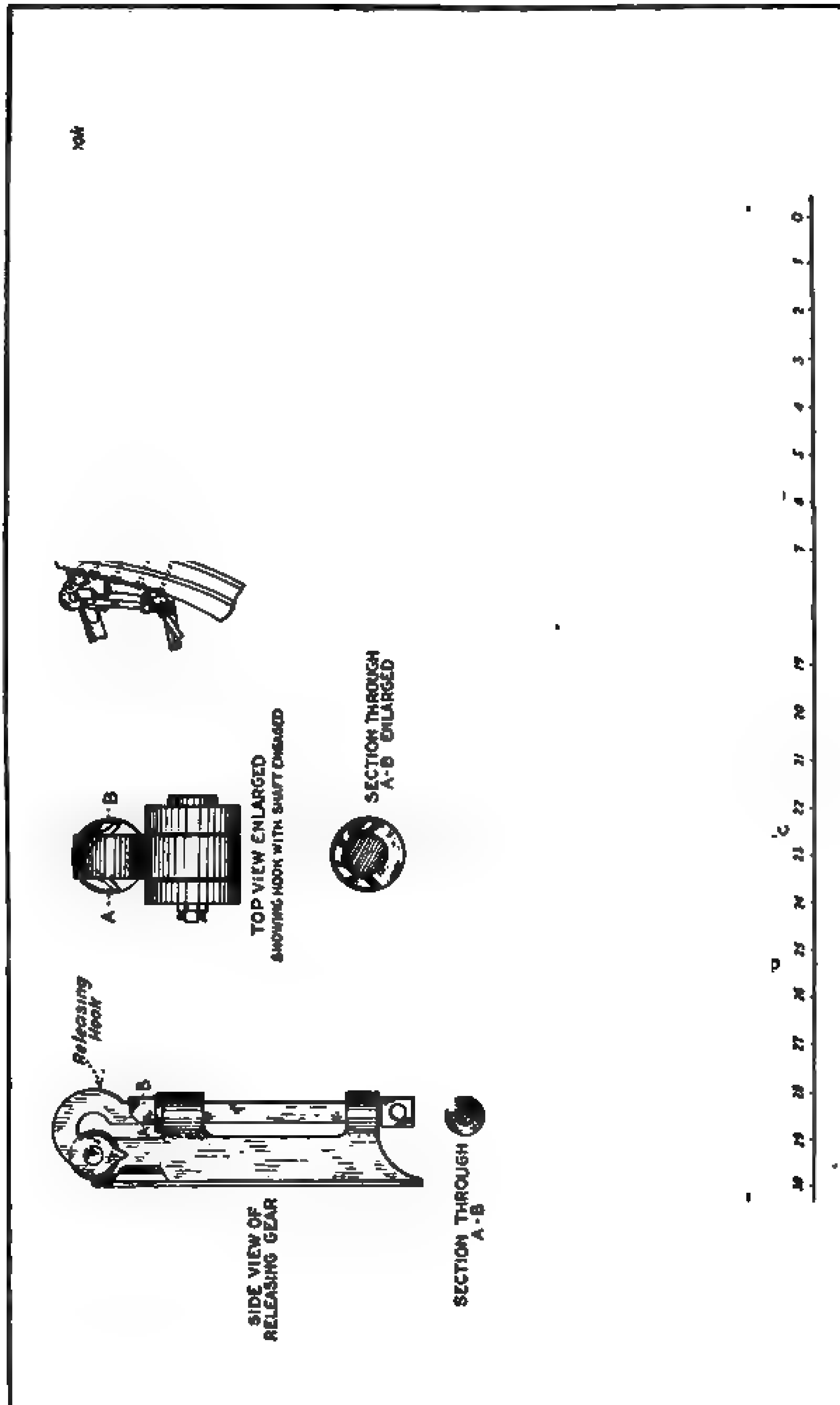
Thus the key to the working of the gear lies in the position of the cupped head of the locking bolt; and this is regulated by the position of the rod, which, as already stated, runs the length of the boat and connects the mechanism at the two ends.

The turning of the rod, and hence of the locking bolt, is determined by the position of a lever, shown in the sketch. When this lever is in the upright position, where it is secured by a pin, the locking bolt is in the locking position, the point of the detaching hook is held secure, and all is ready for hooking on.

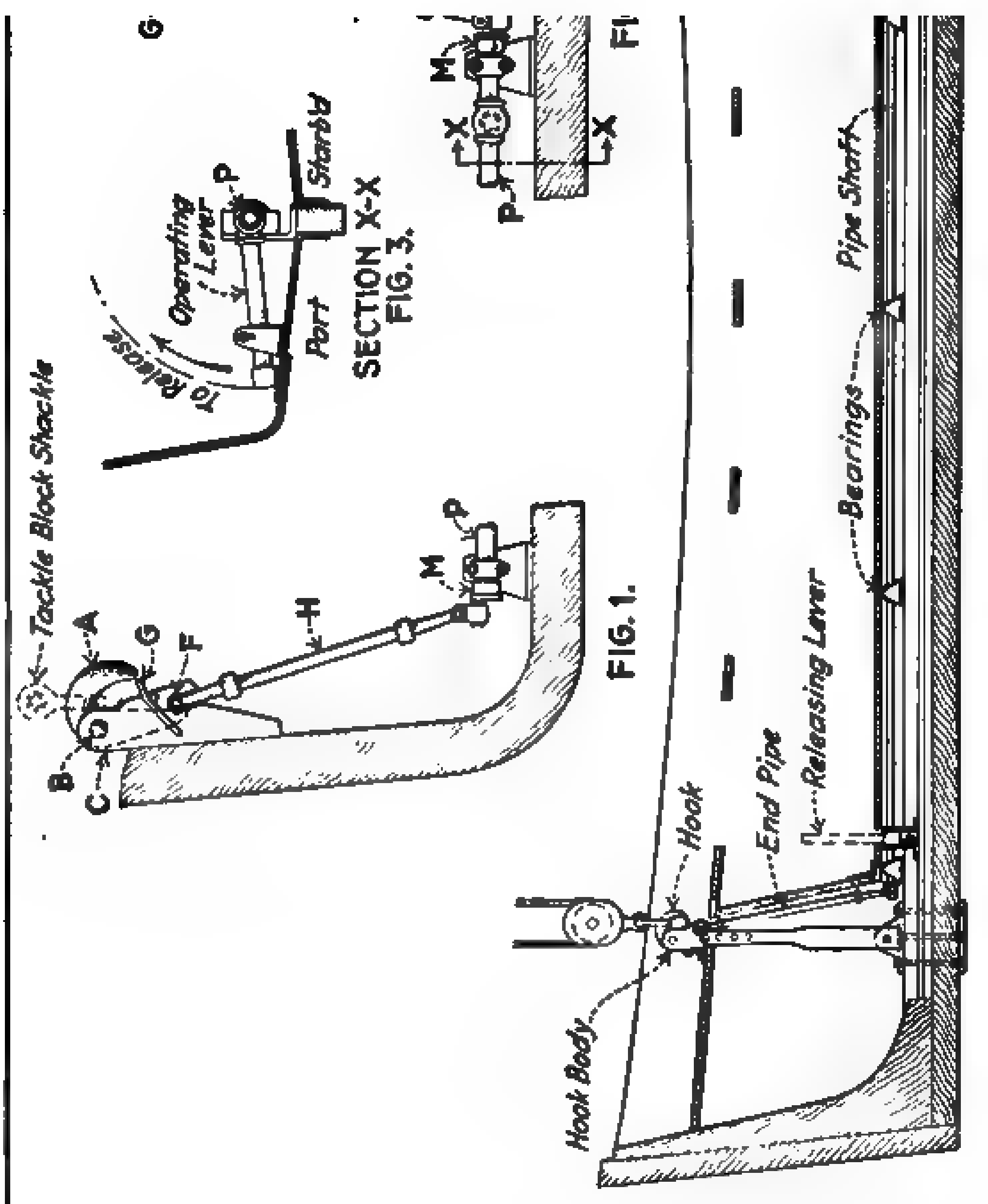
If the lever is turned down, the locking bolt revolves, bringing the open section of the cup in line with the point of the hook, which is thus released.

Steward Releasing Gear. (Plate 74.)

In this device, the boat is held by a lifting hook, *A*, which hangs *eccentrically* on the pivot-bolt *B*, between the side-plates of the frame *C*. The hook is extended beyond and below the pivot bolt by the shank, *D*, which, in the normal position of the



ROTTMER DETACHING GEAR.



STEWARD RELEASING GEAR.

gear, is prevented from swinging (to capsize the hook) by the clevis bolt *F*. With the gear in this position (Fig. 1) the link of the lower tackle-block may be engaged in the hook by slipping it past the retaining pawl, *G*, which lifts freely but drops back immediately and holds the link from unhooking. Fig. 1 shows the condition of the gear when the boat is hooked on, either for hoisting or for lowering.

To release the link (and the boat) it is necessary that the clevis bolt *F* should be withdrawn sufficiently to let the shank of the hook swing clear, permitting the hook to capsize (Fig. 2). The withdrawal of the clevis bolt is effected by the vertical shaft, *H*, which is drawn downward through the slot *K* by the turning of the eccentric *M*, on the end of the horizontal shaft, *P*. The horizontal shaft is held against turning by the lever, *L*, which is normally turned *down* and securely engaged in a casting bolted to the bottom of the boat (port side) (Fig. 3).

To release the boat, the toggle pin holding the lever in "secure" position is withdrawn, and the lever thrown to starboard, turning the horizontal shaft *P* and with it the eccentric, *M*. The throw of the eccentric draws down the vertical shaft, *H*, and with it the clevis bolt, *F*, releasing the shank of the hook, and allowing the hook to capsize and throw off the link of the tackle-block and release the boat.

To hook on, the hook *A* is turned down to its normal position, the releasing lever thrown down to port and secured, carrying the clevis bolt up to the point where it engages the shank of the hook. The link of the tackle-block is snapped in, past the retainin pawl, and all is ready for hoisting.

The parts of this gear are strong and rigid, and the mechanism direct acting. It appears to comply with the rules which have been quoted as those of both the United States Steamboat Inspection Service and the British Board of Trade.

The Mills Releasing Gear. (Plate 75.)

In this gear the lifting-hook *A* is pivoted in the forked upper end of a lifting-bolt strongly secured to the keel of the boat. On the reverse shank of the hook is a heavy metal ball *B*, the weight of which tends to keep the hook upright at all times, whether the hoisting tackle is hooked or not. The apparatus is mounted in the boat in such a way that the hook stands approximately

RELEASING GEARS.

flush with the bow (or stern) sheets of the boat, with a slot through which the gear is operated. The link *L* on the lower tackle-block engages the lifting hook in the usual manner, and so long as the weight of the boat is supported by the link and hook, the hook cannot be turned to release the link. This means that the boat can be released only when it is water-borne, and then only by the actual lifting of the ball *B* by an applied force. A chain leads from the ball *B* at each end of the boat to a sheave attached to the structure of the boat *above* the ball, and thence along the side to a releasing handle, where the chains from bow and stern are coupled up in such a way that the pulling of this handle lifts both balls (bow and stern) simultaneoulsy releasing both ends of the boat.

The Broady Releasing Gear. (Plate 75.)

This gear, like the Mills, which it somewhat resembles, is much used in the American Merchant service and by the Shipping Board. Its details and operation are made clear in the illustration. It can be worked with the boat either waterborne or clear of the water.

Carrying a Life-boat Rigged Out. (Plate 68.)

As has been already explained, most ships, and practically all men-of-war, when at sea, carry a life-boat hanging from davits on the quarter, ready for lowering in the event of a man overboard (Plate 68). The boat is griped in, to prevent swinging, the gripes being secured by a slip-hook which can be released in an instant. A sea-painter, from a point well forward on the ship, is taken into the boat through a rowlock on the in-board side and made fast to a thwart in such a way that it can be quickly cast adrift, leaving a turn around the thwart. Life-lines are hung from a span between the davit heads. The falls are kept clear for lowering and should be belayed on their cleats (if cleats are used) in such a way that they will not jam. If the boat is not fitted with an automatic plug, two plugs should be at hand and secured by lanyards to avoid possibility of loss. The rudder is shipped, or, better, a steering oar ready in its crutch. Life belts should be in the boat for the whole crew, and water, provisions, compass, lanterns, signals, etc., in place.

To Lower a Boat at Sea in Bad Weather.

Having to lower a boat at sea, a lee boat is always selected, a lee being made, if necessary, by changing the course of the ship.

It is customary to bring the sea a little on the bow, but in this position the lee for the boat is very far from perfect. The ship will roll and pitch considerably, and waves will wash along to leeward, making things very ugly at times. Some seamen prefer to bring the sea on the quarter rather than the bow. Others advise lying in the trough of the sea notwithstanding the heavy rolling.

The best position will doubtless depend upon the build and trim of the ship and the nature of the sea. In any case, oil should be used both ahead and astern of the boat. The ship should be kept moving slowly ahead. A sea-painter from well forward in the waist of the ship should be brought into the boat through the inboard bow rowlock and tended by the second bow oarsman with a turn around the thwart. It must not be made fast.

To keep the boat from swinging, frapping-lines may be passed around the falls, the ends leading inboard and holding the boat close in to the side as it is lowered. In some ships jackstays are fitted from the davit-heads to the side of the ship, with lanyards travelling up and down. A turn is taken with the lanyard under a thwart or around the standing part of the fall and the boat is held in, near the side, as by the frapping-line above described. Under no circumstances should the lanyard be secured to the boat otherwise than as described (by passing it under the thwart and holding on by hand). Life-lines hanging from the davit-head and from the span assist in steadying the boat and give the crew something to hold on to in case of accident. A hatchet in the boat is handy if anything jambs at a critical moment.

The great danger, both in lowering and immediately afterwards, is that the boat will be dashed against the side. The painter brought in on the inner bow as already described helps to sheer her off as she strikes the water, and the helm may be lashed hard-over toward the ship for the same purpose.

A steering-oar is better than a rudder, and where it is used the coxswain sheers the bow out by throwing the stern in as the boat strikes the water.

The after fall is always unhooked first, except when a detaching apparatus releases both ends simultaneously.

Under no circumstances short of the most imperative necessity should a boat be lowered while the ship has sternway, and it is always desirable to have a little headway. There is much difference of opinion as to the speed at which it is safe to lower a boat, an important question in picking up a man overboard. Many officers, having seen boats lowered without accident at speeds as high as eight and ten knots, maintain that it is perfectly safe to lower at this speed. A more conservative view fixes the maximum at something like half this speed. It is safe to say that there is far less danger at five knots than ten, and most practical men would prefer to wait a little longer rather than to take the chance of having to deal with a whole boat's crew in the water.

Lowering a Stern Boat.

Here, as soon as the boat touches the water, the after fall is let go altogether and the boat allowed to swing at once parallel to the course of the ship, towing by the forward fall, which is then unhooked or, in an emergency, allowed to unreeve.

Hoisting.

To hook on and hoist a boat in a seaway is quite as difficult as to lower and detach it. The ship is handled in such a way as to make a good lee, and it is well that she should be moving very slowly through the water, but the screws should be stopped while working with the boat. The falls are overhauled ready for hooking on, but it is a good plan to have a hand at each davit-head holding the blocks clear as the boat comes alongside to avoid danger of hitting the men in the boat. The falls are well manned, with force enough to *run away* when ordered to do so. If a winch is to be used, the proper turns are taken loosely around the drum and the winch is started. The sea-painter, from well forward, is led aft and held in a coil by a good man who stands by to throw it to the bow oarsman in the boat at just the right instant. It is convenient to have a light line bent to the painter near the end for hauling it in for another throw in case of missing the boat.

The officer who is to direct the maneuvre should take his

place on the rail as close as possible to the point where the boat is to be hoisted.

The boat pulls near the ship abreast of her falls or a little astern of them, and waits to receive the line, the bow oarsman laying in his oar and standing by. The line is thrown and caught, and a turn is taken around the forward thwart. The oars are then laid in as quickly as possible and the boat is dropped in alongside the ship and under her falls by careful use of the steering oar; being hauled ahead *slowly*, if necessary, by the sea-painter, which is manned on board the ship by a few men only. If the coxswain is skilful, he will work her slowly in, first canting her head slightly toward the ship and then catching her before she can touch, by throwing her stern in enough to straighten her up parallel to the ship.

Two men stand by to breast her off with boat-hooks if necessary.

If the ship is making way through the water, a line should be used from the stern of the boat, leading well aft on the ship, to hold the boat from launching forward as she leaves the water.

The men who are to hook on forward and aft see the links in the boat ready and stand by with the lower blocks. Oil should be used to calm the sea if necessary. When all is ready in the boat and on deck, watch for a smooth time and as the ship starts to roll toward the boat, hook on forward, then aft; then, "**Set taut!**" "**Hoist away!**"

Man-of-War Rules with Regard to Life-Boats.

At Sea. When at sea, every ship shall at all times keep on each side, ready for lowering, a boat which is best adapted for a life-boat.

At the beginning of every watch at sea, the officer-of-the-deck shall have the life-boat crew of the watch mustered abreast the lee boat, and the coxswain of the life-boat crew of that watch shall satisfy himself by personal inspection that *both* life-boats are ready for lowering, and shall report the fact to the officer-of-the-deck.

A life-boat is secured for sea, *i. e.*, ready for lowering, when in the following condition: Boat at the davits, griped in, falls clear, detaching apparatus ready for detaching at the word, steering-oar shipped in crutch, oars fitted with trailing lines and ready for getting out quickly, rowlocks shipped and fitted with lanyards, plug in, sea-painter half-hitched around forward thwart, life-lines bent to span, life-belts in boat, lantern filled and trimmed (and at night, lighted), and all other articles of the boat-equipment in the boat and ready for use, with two days' water and provisions for the crew. When the coxswain of the life-boat

crew of the watch reports a life-boat ready for lowering, it is understood that the boat is in the above condition and that the crew of the watch have been mustered, each man abreast his own thwart (or station) of the lee boat, and that each man understands his duties at "Man-overboard." In lowering, the officer or coxswain in charge of the lifeboat will give the command for detaching.

EQUIPMENT OF BOATS.

In preparing a list of articles for the proper equipment of a boat, it is necessary to consider the service for which the boat may be needed. One which is to be carried at the davits ready for lowering at a moment's notice to pick up a man overboard calls for a very different outfit from one which is never to be used except in case of disaster to the ship.

The following list includes all articles of ordinary equipment; others may be needed for special service of various kinds:

1. Set of oars, with spare for one thwart, with trailing lines if used.
2. Set of rowlocks, if used, secured by lanyards, with two spare.
3. Set of stretchers.
4. Plug, secured by lanyard, unless boat fitted with automatic plug.
5. Rudder and tiller, with lanyards.
6. Three boat-hooks.
7. Breaker, kept filled with good drinking water and carrying three days' supply for crew.
8. Fenders.
9. Compass.
10. Lantern.
11. Bucket.
12. Boat-box containing tools and material for meeting emergencies which may arise on distant service.

Items 1 to 12 are, as a rule, kept in all boats at all times, except that the compass and lantern may be removed for safe-keeping when the boat is not to be used for some time.

13. Anchor, with chain or good line.
14. Sails and spars, or sea-anchor.
15. Tarpaulin.
16. Boat's ensign, with staff.
17. Hand grapnels, with light chain or line.
18. Rifle and shot gun, with ammunition.
19. Provisions; usually bread and canned meats, and emergency rations.
20. Night signals or other fire-works of some satisfactory kind for attracting attention at night.
21. Hand signal flags.
22. Crutch and steering oar for boats using them.
23. Life belts (life boats only).

Items 13 to 23 are kept in the boat whenever they are likely to be needed.

24. Package medical and surgical "First Aid" supplies.

25. Sextant and general chart. (Put in at time of emergency if indicated by conditions.)

The English Board of Trade rules require sails and spars, and a sea-anchor. The insistence upon sails and spars clearly contemplates the possibility of a trip of some length after leaving the ship. No doubt such trips have been made by boats under sail, but in a great majority of cases the space occupied by the sails and spars could be utilized to better advantage for passengers, even if the boat were reduced to waiting helplessly for a passing vessel. A sea-anchor would be useful in a gale, but need only be carried if sails are omitted, as these two would never be wanted at the same time and the sails and spars lashed together (with sails loosed) make a perfectly efficient sea-anchor.

Handling Heavy Boats by a Crane.

The heaviest boats carried by merchant vessels do not as a rule exceed about 5 tons in weight, and the problems of lowering and hoisting them present no serious difficulties except such as arise from unfavorable conditions of weather, collision, etc. They are in practically all cases handled by davits; and the mechanical davits and releasing gears already described have solved many of the problems connected with their use.

The steamers and motor boats carried by men of war may weigh as much as 20 tons. They are handled by booms or cranes of special design, and extra heavy fittings are provided for hoisting and lowering.

Plate 76 shows the boat-crane of a battleship and the slings and other fittings for hoisting a 20-ton boat. As the slings and the crane-block are heavy and unwieldy, the matter of handling them is always difficult and becomes not only difficult but dangerous when the boat is tossing about in a rough sea. The matter is greatly simplified by the use of the *safety runner*[1] shown in Plate 76, which has been officially adopted as an attachment to all boat-crane hooks.

The following description of the runner and its uses is from a circular issued by the Bureau of Construction and Repair under date of May 2, 1916.

[1] Devised by Captain W. L. Littlefield, U. S. Navy.

Plate No. 76.

HANDLING A HEAVY BOAT.

"The device consists of a wire about 3½ fathoms long made fast to the hook of the lower crane block. The wire has an eye splice worked in the free end and the standing part is rove through a ½ inch hole drilled about three inches long, axially, in the point of the hook, and the end knotted. The sketch shows a more flexible fastening to the point of the hook.

"It is useful in hoisting boats in a heavy seaway as the wire may be rove through the ring of the slings, and a heaving line bent to the eye splice, the other end of the heaving line being kept on deck. The ring of the slings and the crane block remain above the heads of the crew and clear of such parts of the boat as might be damaged, until a comparatively calm spell presents an opportunity for hoisting, when, by quickly taking in the slack of the heaving line, the wire will run the ring on to the hook.

"It is particularly serviceable in lowering the slings of steamers into a boat for hooking on. In this case the wire is rove through the ring of the slings, and a line from deck bent to the wire, before the slings are sent down to the steamer. The crane block is lowered just far enough to permit the wire to take the *weight of the slings* while they are being made fast, the end of the line on deck being hauled in and paid out just enough to keep control.

"As before, when a comparatively calm spell presents itself, lowering the block slightly and heaving in on the wire will run the ring onto the hook and the boat can be hoisted.

"This arrangement also serves for quick detachment and is better than a toggle and strap for this purpose. In this case, the ring of the slings is put over the point of the hook *and the bight of the wire.* Hauling on the wire will straighten the bight and lift the ring clear of the hook as soon as there is the least slacking of the slings."

Where a heavy boat is to be lowered or hoisted at sea in bad weather, the ship brings the sea a little on the off bow to give a lee, and uses oil if necessary, making a "slick" in which the boat will be comparatively quiet. The ship may be stopped, or making just enough way through the water to maintain the course that is found best for the boat. If the ship is moving it must be remembered that the boat will tend to surge forward as it leaves the water. This calls for a good stern line leading well aft, in addition to the regular steadying lines, bow and stern, which are always used in hoisting a boat at sea. If the ship is rolling enough to involve danger that the boat will swing in against the side, special fenders should be provided. For improvised fenders, hammocks answer very well.

All preparations having been made, including hanging the slings from the bight of the safety runner, the boat is brought

under the crane, the boat rope and steadying lines are passed, and the crane-block is lowered. The slings hang slack in the bight of the runner while their lower ends are hooked in the boat, Fig. 1, Plate 76. When all is ready, advantage is taken of a quiet moment to run the ring of the slings into the hook of the crane-block and start the winch:

In getting out the boat (at sea), the ship makes a lee as for hoisting, the boat-rope and steadying lines are passed as before, except that no special stern line is needed. The boat is lowered until just clear of the water, and at a favorable moment is lowered quickly. As soon as it is waterborne, slacking the slings, the ring of the slings is run clear of the hook by a pull on the runner, which in this case is rove as in Fig. 4.

It will be noted that the safety runner as thus used is a simple and very efficient releasing apparatus.

§ III. NOTES ON THE CARE OF STEAM LAUNCHES AND MOTOR BOATS OF MEN OF WAR.[1]

Each steam launch should have two crews, assigned to different watches in the engine room, so that there will always be one crew off duty and ready to go in the boat when the ship enters or leaves port, without calling upon men to leave their stations in the engine room. Any man of ordinary intelligence can soon be taught how to do the routine work required of the fireman and coal passer, provided that one of the mechanics of the ship exercises strict supervision of the machinery and keeps it in repair.

When a vessel is about to enter port notice should be given one-half hour or more in advance to the fireman in charge of the launch, who should see that the boat is supplied with fuel and fresh water, that all parts of the machinery are connected, that bolts, nuts, keys, split pins, oil cups, steam- and water-gauge lamps are in place, all usual and necessary tools on board, the boiler filled to proper level with fresh water, the cocks at the top and bottom of the water gauge open, and the engines oiled and turned by hand.

The water used in the launch boiler should always be obtained by distilling on board. Fresh water from shore often

[1] Although steam launches are being gradually replaced by motor boats, large numbers of them will continue in use in the Navy for many years.

contains corrosive ingredients or lime salts, and should never be used unless chemical tests show that it is free from these impurities.

When the launch is about to be lowered it will often be practicable to start fires at once and to have steam ready by the time the boat is in the water. As soon as the launch is in the water, if not before, the feed pump or pumps must be worked by steam, the engines turned back and forth, the whistle, safety valve and bell tried. If at such times any of the machinery fails to work it is better to try to discover the cause by reasoning and by simple experiments rather than to use up time taking the machinery apart to see what is wrong inside, and to run the risk of twisting off studs, losing nuts and spoiling gaskets.

Reciprocating Engines. If an engine or pump stop-valve is detached from its stem, and steam-pressure is on top of the valve, no steam gets to the engine and none comes out of either cylinder drain.

If steam comes out of both cylinder drains at the same time, the slide valve must leak.

If opening the drains shows that there is a good head of steam against one side of a pump piston and the piston does not move, then there may be a stop valve shut in some part of the exhaust pipe, or a stop valve in the exhaust pipe may be off its stem and kept shut by the pressure of the exhaust steam.

If on opening the drains it is found that there is a good head of steam acting against the piston and the piston does not move, shut off steam and open the drains on the water end and let out the water, then use a lever and try to move the pump piston by hand and see if it is stuck. It may be stuck from the steam piston being rusted in place, or from the piston rod stuffing box being set up too tight when the rod is worn unevenly, or the packing in the water cylinder may be too tight when the water cylinder is worn barrel shape.

If the pump starts, makes a few strokes and stops, it would indicate a valve in the exhaust closed, or a check closed.

If the pump runs but does not throw water, the causes may be:

(a). The water in the feed tank is too hot so that vapor forms in the pump. The vapor can be condensed by pouring cold water over the pump.

(b.) One or more of the suction or delivery valves may be unseated or stuck open by waste under them. In this case it will be necessary to remove one or more bonnets to get at the valves.

The pump may run and throw water so that a strong jet comes out of the pet cock on the discharge side and yet no water gets into the boiler. This may be due to the pump piston or valves leaking under boiler pressure, yet not so much as to prevent the pump throwing water under atmospheric pressure, or even a little above. If such leak is suspected, try reducing the boiler pressure to see if the pump will feed at any pressure and thus enable the boat to continue in service until opportunity occurs to repack the piston or refit the valves.

The pump may make a few strokes then gradually slow down and stop. This would indicate that the boiler check valve was stuck, or the stop valve at the check was detached from its stem. If the check is stuck, it can often be loosened by rapping on the valve chamber with a light hammer or bar of iron or by pouring cold water over it. If the stop valve is off the stem, nothing can be done until the fires are hauled.

A common cause of the failure of naval pumps is the slipping of the valve tappets, and this is the first thing to be looked for.

Each type of engine and pump has its own peculiarities, which must be learned by experience. No pains should be spared to get all parts into thorough repair, and when the boat is not required for service no temporizing with machinery which works imperfectly should be tolerated. The labor required to go through the routine overhauling of all parts of the machinery is far less than the labor of repairing breakages which are sure to result from neglect of such systematic overhauling.

While the launch is alongside the ship the furnace should be fired as lightly as possible to avoid blackening the ship by the smoke that is given off when firing heavily. For the same reason the use of the steam jet is to be avoided at such times.

When the launch shoves off and gets fairly under way, the first point to notice is the vacuum, and if that is below normal, search must be made to ascertain the cause. The feed water should also be *tasted* to see if it is salt and this test repeated from time to time while the launch is in use. The firemen

should carry a uniform steam pressure, fully up to that prescribed for the boat. Inability to do this shows something wrong with the engine, boiler, the fuel, or with the men; and the exact reason should be discovered and the difficulty overcome. The most common causes of low steam are too heavy firing, too high water in the boiler, and tubes which require cleaning. Any kind of coal likely to be bought by men-of-war will burn well if *lumps* are selected for use in the launch. As the men gain experience and confidence in themselves and the feed pump, they are inclined to carry water lower than the normal level because they find that the boilers steam more freely. The principal danger to be anticipated from this is that a temporary failure of the pump may result in the water disappearing from the glass, in which case there is no way of knowing how little water may be in the boiler, and it might therefore become necessary to haul the fires. While under way the water in the gauge generally rises and falls with the motion of the boat. If it remains motionless, it would indicate that the gauge was choked. If the water in the gauge shows a muddy color, or a drop of oil floating on the surface, it would be an indication that the boiler needed cleaning badly. Absolutely no oil should be used in any steam cylinder except when the machinery is to be laid up for an indefinite time, say not less than several months. In this case it should be applied by removing the cylinder and valve chest covers, wiping over the surfaces with waste dipped in mineral oil and replacing the covers. A groaning noise, which often occurs in the L. P. cylinder of a compound engine, especially when the engines are slowed after running full speed, is not an indication that oil is needed in the cylinder. When the engines are in free route, a sudden slowing down is sometimes noticed. It may be due to an increased resistance encountered by the boat from changing the course bringing the wind from astern to ahead; or to the boat leaving deep water and running into shoal water; or to the propeller fouling or the helm being suddenly put hard over; or some bearing, especially a crank pin, may be heating, or the water in the boiler going over into the engine, or the vacuum may be spoiled by an air pump valve carrying away, or there may be a drop in steam pressure from improper firing, or the water in the boiler may be run up too high and too quickly. A hot crank pin or

other bearing should never occur with such engines as are now used in launches. If water gets into the cylinder to any extent a knocking sound will be heard, and the drains cannot be opened too quickly. Such an accident ought to be most carefully guarded against as it is very apt to cant the piston and bend the rod. It is caused by irregular firing, carrying the water too high, the steam too low, or suddenly speeding up the engines.

If when the engines are in free route a sudden great increase in the number of revolutions is noticed, it is an indication that the propeller is lost or one or more blades are broken off. Slight increases may be due to the wind and change of depth of the water, &c.

In case the water cannot be kept in sight in the glass owing to failure of the pump or a leak in the boiler, it will be necessary to haul the fire. In this event a shovelful of live coals may be left in the furnace to start a new fire with. If the leak is so great that fires cannot be hauled without risk of scalding the fireman, there is no objection to putting out the fire with a bucket or two of water.

Every effort should be made to avoid the necessity for using salt water in the boilers, and to prevent it getting in from a leaky condenser. If the condenser leaks, the mixture of salt and fresh water from the air pump may be allowed to go to waste and fresh water from the reserve tanks used exclusively for feed provided those tanks carry enough water to last until the boat returns to the ship. If, however, it is necessary to use salt water, the boiler should be emptied and washed out with fresh water at the earliest opportunity, and if much salt water has been used it may even be necessary to use kerosene to remove the lime scale from the tubes.

Although the tubes of launch boilers are not found to corrode to anything like the extent that the tubes in the main boilers do, it is well always to keep the water in the launch boiler slightly alkaline by use of a small quantity of caustic soda or caustic potash in the feed from time to time when the launch is in use, and especially when the launch is hoisted; except that when the weather is so cold that there is danger of the water freezing, the boiler must be kept empty. The amount of alkali used should be just enough to turn red litmus paper blue.

In a seaway the water gauge glass must be screened, as cold spray striking the hot glass is apt to crack it. If the glass is broken the water level can be judged by using the pet cocks, or if none are provided, then by allowing the lower cock of the water gauge to drip slightly. A thumping sound is sometimes heard under the stern when the engines are running and the helm is suddenly put hard over or if the water is rough. This indicates that the bushing in the stern tube is much worn and needs renewal.

When a launch returns alongside of the ship the fireman should report to the coxswain before the latter leaves the boat what repairs or supplies are needed in order that the officer of the deck may get prompt information on these points.

When a launch is to be hoisted on board all necessary pipe joints must be broken and preparations made for removing the engine or boiler or both if the amount of repair work required renders it necessary. As soon as the boat is hoisted in, an inspection is made of the propeller to see that none of the blades are bent, that the nut is secure with its split pin, and that there has been no corrosion of the shaft close to the propeller hub. It frequently happens that the shaft corrodes deeply at this point and then a slight blow from the propeller striking a piece of drift wood or other obstruction breaks the shaft, disabling the boat and causing the propeller to be lost. If any blades are bent they can be hammered out to their proper form. If a blade is broken off it is sometimes practicable to have a new one cast on.

An examination must be made to see if the lignum vitæ bushing of the stern tube is worn down, and if it is a new spare bushing should be fitted. If there is no spare bushing or lignum vitæ block in store, a temporary bushing may be made of anti-friction metal.

All the under-water fittings of the rudder should be examined and put in good order. The keel condenser can be tested for leaks by filling with water and afterwards draining by removing the plug provided for that purpose. A question arises as to whether or not the keel condenser should be painted. It is inconvenient of access when the boat is hoisted, and unless cleaned daily it is an unsightly object if left unpainted when the bottom of the launch is painted. Paint protects the copper from corrosion when the boat is in the water but diminishes its conductivity to some extent.

The following spare parts are usually provided: Boiler tubes, grate and bearing bars with their patterns, water-gauge glasses, brasses for the engine, propeller shaft, propeller, keel condenser. Except the special tube expander and steam-tube sweeper, such tools and stores as are found in the ship's store-room will do for the launch. It is convenient to have on board in or near the machine shop, suitable pipe and connections arranged to facilitate testing the engines, boilers and pumps after they have been repaired and before they are replaced in the boat.

A water-tube launch boiler using only distilled water should be cleaned at least every three months. If, however, the boiler gets much scale or oil in it, the most effective way to clean it is to pump into the boiler with the feed water a few pints of kerosene lamp oil while the boiler is in use. The first effect of this will be to loosen up the dirt, and the water in the glass will appear very cloudy. Then blow down to the bottom of the glass and repeat the operation until the water in the glass gets clear.

When the engines and boilers are removed for repairs, an opportunity is offered for thoroughly cleaning and painting the bilges, repairing floor plates, water tanks, coal bunkers and such parts as are inaccessible at other times. New bearing bars and grate bars are to be fitted when required. The prolonged use of bent bars wastes coal and makes it difficult to keep up steam.

After the engines and boilers are repaired and replaced all bright work should be kept clean, the polished steel being covered with the thinnest possible coat of mineral oil, all oil holes plugged, and the engines and pumps moved by hand every day. The boiler may be painted with asphaltum or brown zinc. If the latter is used, it can be kept in excellent condition by wiping it over from time to time with oily waste. The best way to preserve the boiler is to keep it completely filled with water made slightly alkaline with caustic soda (or caustic potash) except in freezing weather, when it must be kept empty and as dry as possible, all openings being closed to prevent access of air and thus retard corrosion.

If the boiler is of such a type that it cannot be completely drained, it may be dried out by using a very light wood fire or large lamp, at the same time raising the safety valve and noting

when vapor ceases to come off. In cold weather the engines, pumps, pipes and condenser must also be kept drained. It is well to provide tarpaulins for engines and boilers, putting them on in wet weather and removing them promptly when the weather clears. Launch machinery being out of sight when the boat is at the davits or on the skids, it is apt to be neglected in this as well as in other respects. At sea it is preferable to cover the polished steel-work of launch machinery with a mixture of white lead and tallow instead of the thin coat of oil, as in stormy weather it is often difficult to clean the machinery, and salt spray washes off the oil.

The officer in charge of a launch will find it convenient to keep for reference a memorandum of the size and weight of the boat, the type, weight and number or other distinguishing marks of engines, boilers and pumps, a list of necessary tools, stores, amount of coal, water and oil usually carried, the maximum speed of the boat and revolutions of engine, the steaming radius, amount of extra coal, water and oil required to cover a given distance at the desired speed, the allowable steam pressure, the usual vacuum attainable when all parts are in good order, and the greatest number of passengers the boat can carry. This data will be found convenient when about to order stores or spare parts, when instructing a new crew, or fitting out for a long trip.

Special Notes for Turbine Engines. The coxswain should remember that turbines have not the backing power that a reciprocating engine has, and should come alongside of the landing very slowly and not depend on his engines for checking his speed too much, when making a landing.

The valve to the scoop should be opened as soon as the boat has headway, but kept closed at all times when backing or the boat is stopped.

The lubricating oil pumps should be running before any attempt is made to start the turbine, and the oil circulating to all bearings and the gear.

The turbines should be warmed up well before the engine is started.

The drains from the turbines should be opened to the condenser, at all times when the engine is not running or the engine is being warmed up.

When starting to warm up, steam should be opened to the glands, and after the boat is under way, the steam to the glands should be turned off, and turned on again when the boat is stopped.

The speed of the air pump should be so regulated to give a vacuum of 25 inches or more.

The air ejector should never be used except as an emergency, as it heats the feed water to such a high temperature that the feed pump takes its suction with difficulty, and vapor forms in the water seal to the turbine and causes the vacuum to fall.

If, after getting under way, the vacuum does not increase to 25 inches, examine the glands, and see they are getting plenty of water, and that the condenser is cool and the air pump is running at proper speed; then if the vacuum does not increase there are air leaks in either the turbine or exhaust lines.

When running, always keep about 5 inches back pressure on auxiliary exhaust line, as this is necessary to prevent air leaks into the condenser, and to heat the feed water and fuel oil.

When the boat is hoisted in for overhaul, the gear case should be opened up, gear examined and smoothed up with a file or oil stone by an experienced machinist.

The lubricating oil should be taken out of the system frequently and thoroughly cleaned, as more trouble is caused in a geared installation by improper lubrication, than for any other cause. The forced lubricating system should be thoroughly examined and cleaned out at the time.

The clearance on the turbine should also be taken and the thrust block properly set.

If the fuel oil burner should go out, it would probably be caused by either the burner tip being covered with carbon, or water in the oil. In such case, clean burner and shift the fuel oil supply to another tank, until the water can be drained out of the tank.

If, after getting under way, the boiler smokes, it will probably be caused by forcing the boiler too much; the blower not supplying sufficient air; cold fuel oil supplied to the boiler; or the fire side of the boiler being dirty.

To overcome the smoke, see fuel oil at proper temperature, and speed up the forced draft blower and slow down slightly if necessary.

When stopped, the vacuum can be kept fairly high, if proper attention is given to the steam glands, and shifting from the scoop injection to the circulating pump; but when backing, the vacuum will of necessity drop somewhat.

In getting up steam from a cold boiler, turn steam on atomizer for steam atomization until boiler is hot, then close off steam and use atomizer as continuous flow pressure atomizer.

Motor Boat Engines. There are now in the naval service numerous types of internal combustión engines installed in ships' boats. The standard types vary, in 2-cycle construction, from the small 5 horse-power dory engine to the 20 horse-power engine used in sailing launches. In 4-cycle construction, engines of 100 to 150 horse-power are used in motor "speed-boats."

The 2-cycle engines operate at revolutions per minute up to 600. The 4-cycle speed boat engines are of the light high speed type and operate at revolutions per minute up to 1,500.

Besides the standard types mentioned above there are numerous commercial engines in service of various types and sizes. In general, a "heavy duty" engine of rugged construction, low speed, goodly reliability with average attendance, are required for general utility and varied service. A "light duty" engine of light weight, high rotative speed, with reliability rather dependent on expert attendance, is used for express service.

In handling a boat fitted with internal combustion engines, care should be taken in making landings, the speed being so regulated in coming alongside as to prevent the necessity of throwing out the clutch when the engine is running at full speed, as to do this would cause the engine to race and in time to tear itself to pieces.

The fuel generally used is gasoline, for which tanks are provided in the boat. Any commercial grade of gasoline running from 62 to 70 proof will work satisfactorily. In cold weather there may be a little difficulty in starting on a low proof gasoline, but if a high grade is used for priming, the engine should start, and after it is warmed up the low grade fuel can be used.

The supply tanks should always be above the carburetor, so that the fuel will flow by gravity. The tanks should be thoroughly tight and fitted with a drain to lead overboard. All joints in the fuel line must be thoroughly tight and should be soldered. Strainers should be fitted in the fuel tanks and a separator in the fuel line to prevent any dirt reaching the carburetor.

Extreme care is needed in the handling of gasoline, as its vapor is explosive. It begins to vaporize at low temperatures and the rate of vaporization increases with the temperature, so that it vaporizes much more rapidly in the tropics than in cooler climates.

The two most important factors in the running of an internal combustion engine are:

The *ignition* on the engine and the *mixture* entering the cylinder.

If both of these work properly, the engine is bound to run.

The ignition is always high-tension, jump spark. All wiring should be heavily insulated and protected.

It is of the greatest importance to keep the ignition perfectly watertight. No wiring should ever be run in the bilge of the boat. All ends of the wiring should have permanent marks to show where they connect, and the connections to the engine should be marked to correspond.

The plugs must be frequently examined and kept scrupulously clean.

The magneto should be placed high up on the engine to keep it out of the dirt and water of the bilge.

The engines, whatever their size, should have a covering which is perfectly watertight, as it is very important that they should be kept absolutely dry. For small engines a detachable covering may be fitted which can be easily removed when the necessity arises for overhauling the engine. The larger engines should be placed in a separate watertight compartment.

In cold weather the carburetor and the inlet pipe are liable to freeze as a result of the vaporization in the pipe. If the air to the carburetor is warmed and the inlet pipe is jacketed by warm water or heated air, no trouble will be experienced. The jacket on the inlet pipe should be so arranged that it can be cut out in warm weather and a shutter should be fitted in the hot air pipe to the carburetor for regulating the temperature.

Three pumps should always be used in connection with an internal combustion engine equipment; one circulating, one bilge, and one air pump. No bilge water should ever be pumped through the jackets.

No chain, belt, or friction drive should ever be used in any engine equipment.

The engine should be kept well lubricated and should never be allowed to run above the rated number of revolutions or to race when coming alongside.

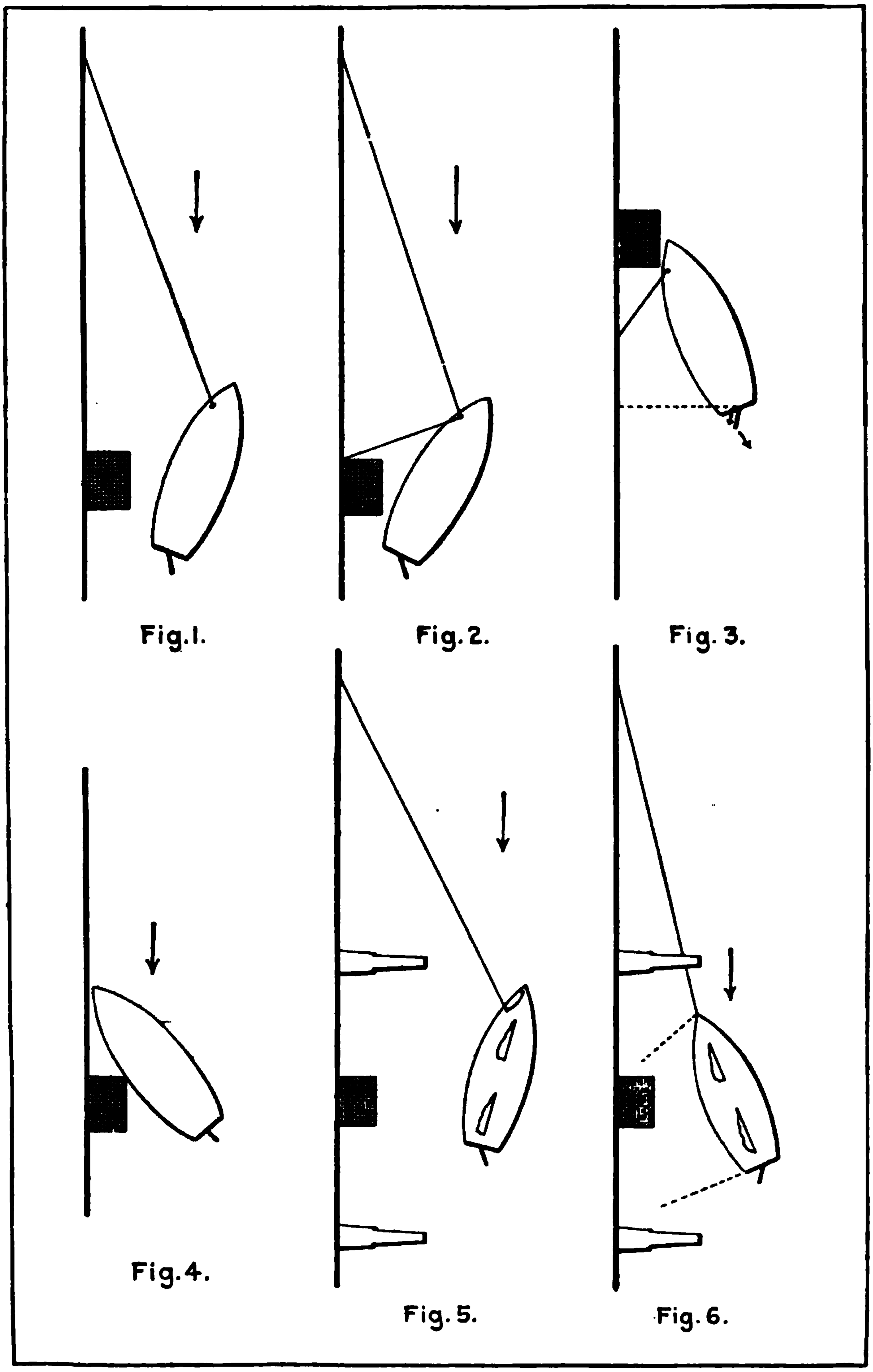
Handling a Launch or Motor Boat Underway and Alongside.

The laws governing the steering of a power boat are identical with those laid down in Chapter XI for the handling of single-screw steamers.

When running in a seaway, speed should be reduced somewhat, not only to avoid shipping seas, but to reduce the strain on the machinery due to the "racing" of the screw. In running into a sea, it is possible by careful nursing to make fair speed, watching the seas and slowing or even stopping for a moment as heavy ones are seen bearing down upon the boat. If the man who is running the engine has sufficient intelligence and experience to regulate the speed in this way (assuming that he can see) it is convenient to leave it to him. If running more or less across the sea, it is well to head up momentarily for a heavy wave.

In towing, the stern of the boat should be kept well down by shifting weight aft if necessary. This keeps the propeller well immersed and gives it a good hold on the water.

In making a landing, whether at a dock or at a ship's gangway, it is a common mistake to keep too much way and to rely upon backing full speed to stop the boat at the proper point. This is bad seamanship. The engines may and often do fail to respond promptly, and when they do respond, the sudden backing throws an undue strain upon the engines and upon the rudder-stops. Moreover, the backing throws the stern off to one side or the other—according as the screw is right- or left-handed. In coming alongside a ship's gangway, in a current, care must be taken not to catch the tide on the outboard bow, as this will sweep the bow in, forward of the landing platform and perhaps underneath it, with the result that the boat may capsize or be swamped. The landing should be made by the aid of a boat-line from forward, the boat being kept off a little from the side until the line is fast and then sheered in by the helm.



HANDLING A BOAT ALONGSIDE
UNDER STEAM OR SAIL.

A launch coming alongside in rough weather or in a strong tide-way should always be *required* to take a boat-line, whether the coxwain and bowman think it necessary or not. It has come to be the custom in the navy for the crews of steamers to make their landings at the gangway by the aid of boat-hooks alone, taking hold with these of anything which may chance to be within reach, and holding on, often with great difficulty and more or less danger. This entirely eliminates the *helm*, which is the one factor by which the whole situation could be and should be controlled. A boat lying at the gangway in a tide-way, holding on by a line from some distance forward made fast to a cleat *on her inboard bow*, can be controlled perfectly by a touch of the helm, throwing the *stern* out or in a little and thus catching the current on one bow or the other. Plate 77, Figs. 1 and 2.

Boat-hooks are helpful and perhaps necessary, at bow and stern, to complete the control; but they are of altogether secondary importance if the coxswain understands that he can sheer his boat when lying in this way in a current, exactly as if she were making way through the water. It is desirable to have the cleat for use with the boat-line as far around on the turn of the bow as is practicable, as this gives a better turning leverage for the helm and the current than if it were near the stem.

If the boat is to lie at the gangway for some time, it is convenient to use a breast line from the bowcleat to a point a little forward of the accommodation ladder, as in Fig. 2. A boat will lie like this in a tide-way with the helm half over to the side toward the ship as long as the current runs.

If for any reason it is desired to hold the bow up to the gangway, a spring may be taken from the bowcleat to any suitable point, as in Fig. 3. Then, by putting the helm over and keeping the engine ahead slow, she can be held in position without difficulty. A stern line is convenient, but is only necessary in the rather unusual case when the wind or current is from aft so that it would tend to throw the stern off too far. This plan is often convenient when we have to hold the launch at some other point than the gangway, for giving her coal which it is desired to land on the forecastle, or for putting in or taking out stores.

A fender is always fitted to the lower platform of the accom-

modation-ladder to keep the boat off and prevent danger of her being caught under the platform. Another fender is usually fitted forward of this to prevent boats from being set in under the ladder and athwart the lower platform (Fig. 4). A boat in this situation is in danger of being swamped. The situation is brought about by the boat having run too far ahead and being caught by the tide on the outer bow. It is a common thing to see a launch come charging up to the gangway under such speed that she cannot be stopped until she has run far ahead of the point where she should have landed, crashing against the fender and scraping along the side, while the men at the bow and stern attempt to catch something with their boat hooks by which they can check her. All this is lubberly in any case and may be very dangerous (especially when the forward fender is not in use) if there is a current tending to set her in under the ladder as above described.

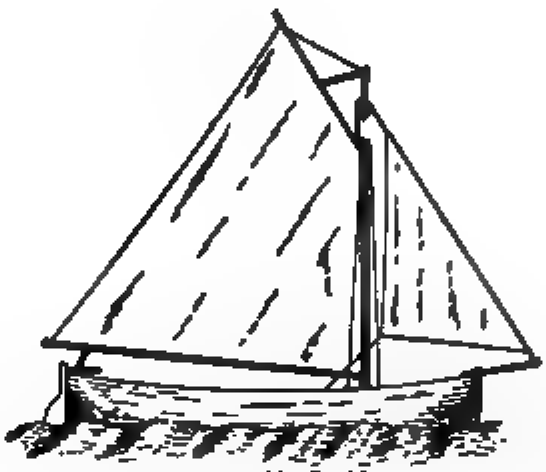
It should never be forgotten in making a landing, that the engine may be slow in responding to signals, and the signal to stop should be given in time to come up to the gangway with very moderate speed.

A good coxswain, in handling a boat in a strong tide or a moderate sea, lands his boat *near* the gangway platform, but not against it, and having caught and made fast the boat line, drops in, by skilful use of his helm, and holds her just where he wants her while his passengers enter or leave the boat.

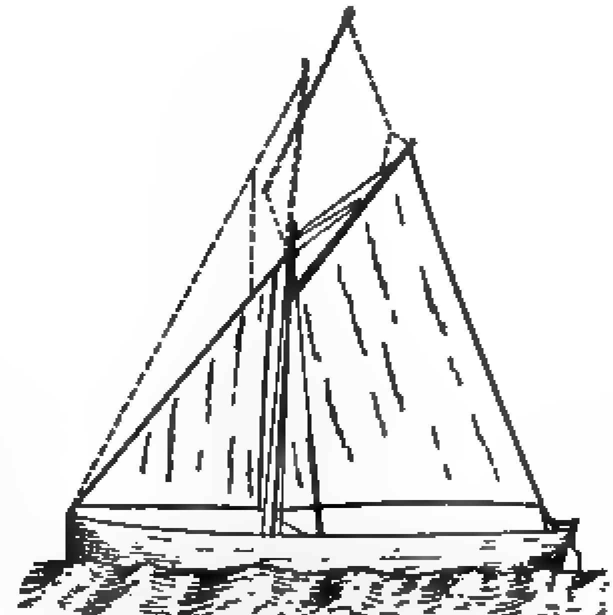
For details of United States Navy boats, see Appendix.

§IV. RIG OF SHIPS' BOATS FOR SAILING.

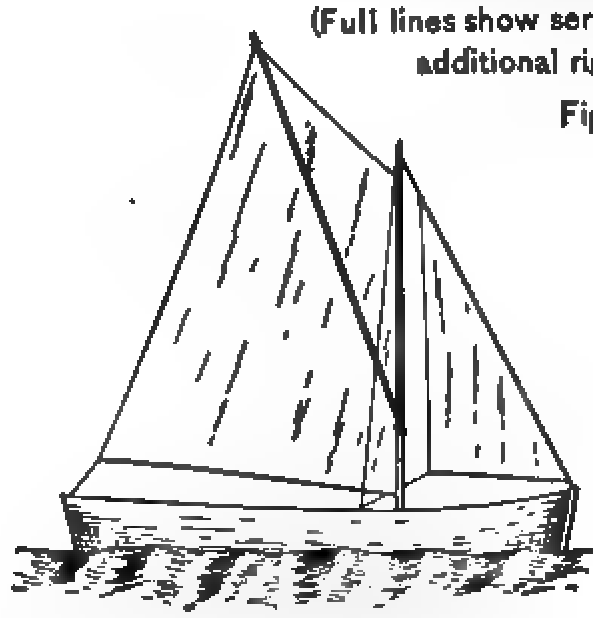
It is not to be expected that a boat built for a great variety of purposes, of which sailing is by no means the most important, should sail as if designed for that purpose alone. Not only must the lines and dimensions of the boat be regulated by the demands of general utility, but even the rig for sailing must be fixed by quite other considerations than those of speed and weatherliness. The spars and sails must be light and easily handled, and must stow compactly when the boat is under oars. They must admit of carrying passengers and stores, of coming alongside safely, of hooking on and hoisting conveniently. The fewer, shorter and lighter the spars, the better. Masts, especially, should be short and light, easily stepped by a few men, and calling for little support from shrouds and stays. Bowsprits and



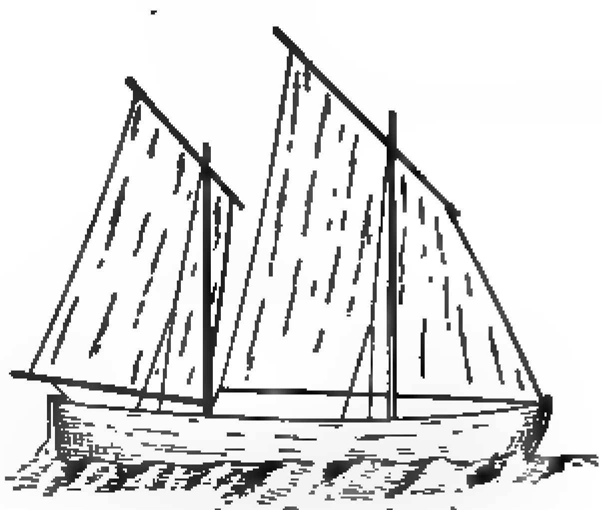
Launch—U. S. Navy.
(Gaff and Boom Rig).
Fig. 1



Launch—British Navy.
(Full lines show service rig; dotted lines additional rig for racing).
Fig. 2



Sprit Rig.
Fig. 3



Dipping Lug Foresail and
Standing Lug Mainsail.
Fig. 4

Standing Lug Mizzen.
Fig. 5

RIG OF BOATS FOR SAILING.

booms are particularly inconvenient, as are also the bumpkins which in some rigs project beyond the stern. A rig which entails danger of capsizing if it chances to be caught aback is of course objectionable.

Of the rigs considered suitable for man-of-war boats, the most common are the following:

1. **A gaff and boom mainsail** with bowsprit and jib. Used in the United States Navy for launches (Plate 78, Fig. 1).

2. **A gaff mainsail without a boom** and a jib without a bowsprit. Used in the English Navy for launches, and called, from the admiral who introduced it, the "De Horsey" rig (Plate 78, Fig. 2). A topmast is sometimes added to this rig, making it possible to carry a gaff-topsail and another jib.

The arrangement devised by Admiral de Horsey for handling the mast of this rig is of such convenience that it might well be adopted for all boats having rather heavy masts to be stepped and unstepped. The mast is mounted on trunnions at the height of the thwarts and as it is lifted, turning about these trunnions, the heel is guided into the step by a light frame shaped to the arc about which the heel moves.

3. **The dipping-lug.** Used in the English Navy for pinnaces and cutters, usually in combination with a standing-lug main or mizzen (Plate 78, Fig. 4).

4. **The standing-lug.** Used in the United States Navy for cutters, and in the English Navy for the main and mizzen of cutters and whale-boats. (Plate 79, Fig. 4).

5. **The balance or French lug.** Used in the French Navy for cutters (Plate 79, Fig. 3).

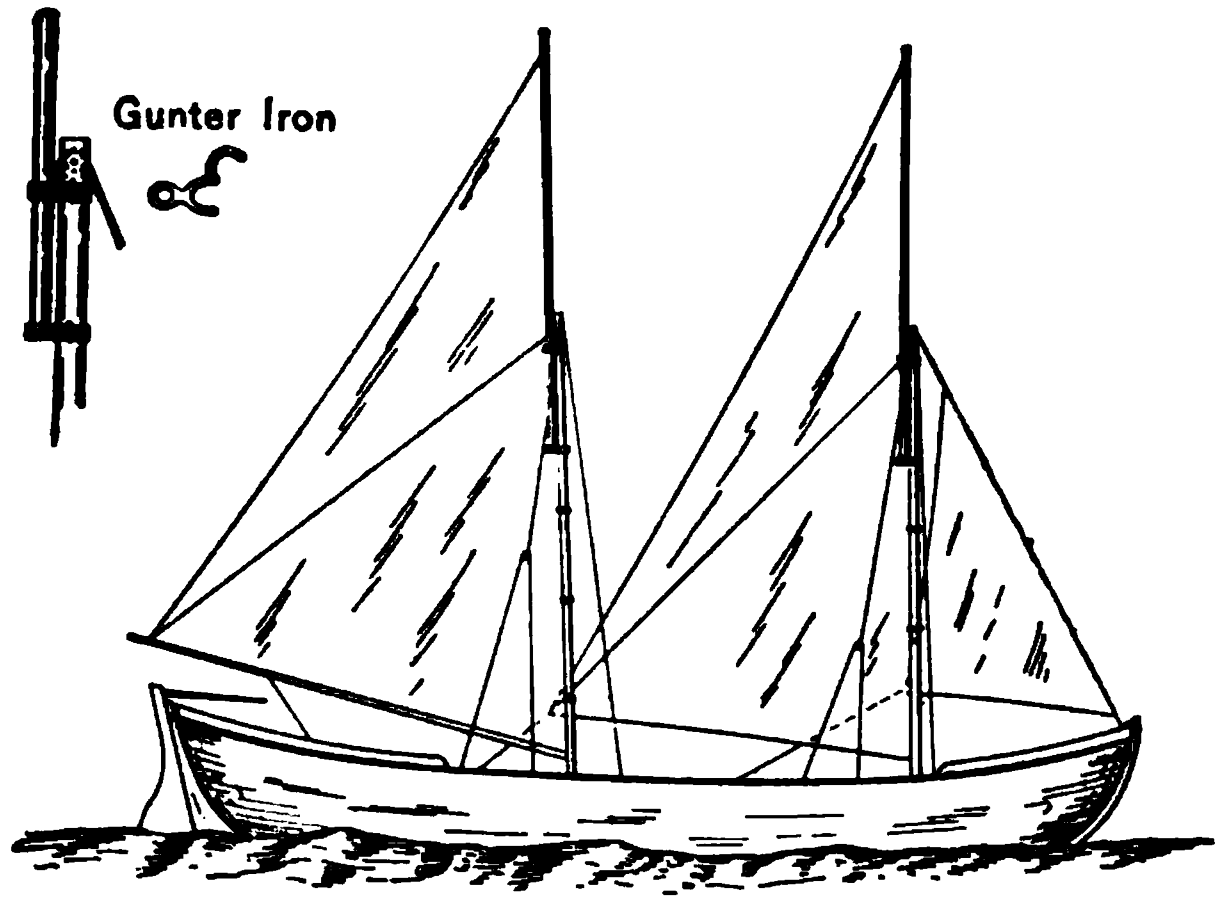
6. **The sliding-gunter.** Formerly used in the United States Navy for cutters, whale-boats and gigs (Plate 79, Fig. 1).

7. **The sprit.** Used very generally for dinghys and other small boats (Plate 78, Fig. 3).

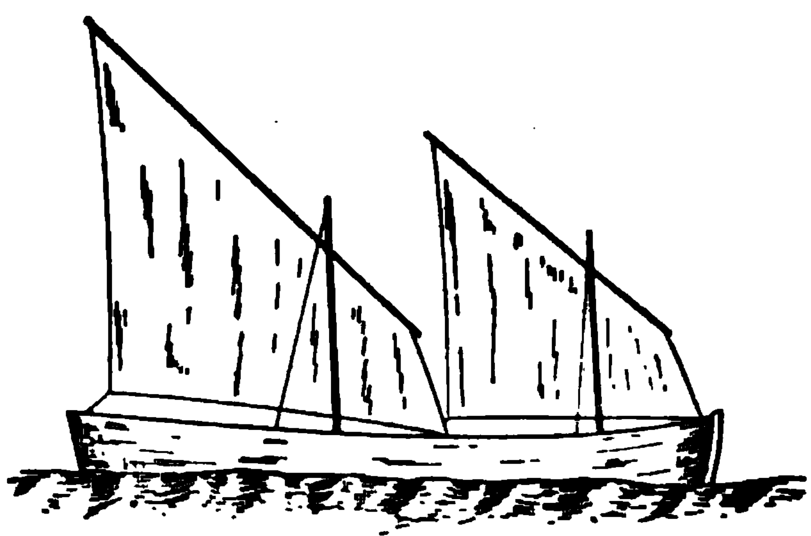
Of these rigs, the dipping-lug is commonly regarded as the best for speed and weatherliness, but it is hard to handle and even dangerous with any other than a very smart and well-drilled crew.

The standing-lug is safe and convenient to handle, but lacks something of the driving power of the dipping-lug.

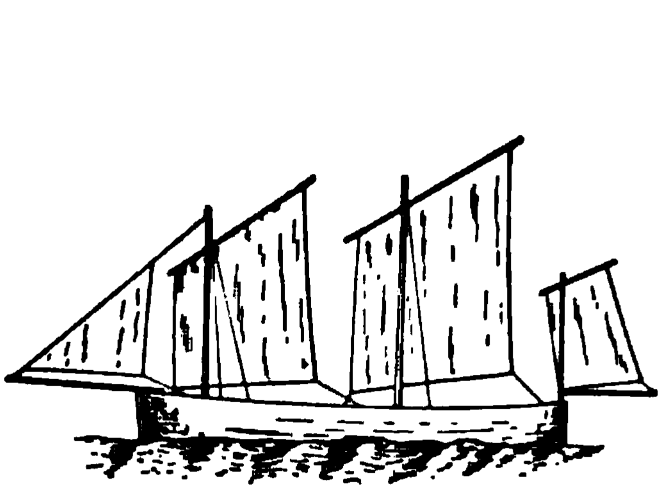
The French lug is a compromise between the two preceding rigs and combines many of their advantages. It may, in fact, be used either as a standing- or as a dipping-lug, the forward yardarm being dipped if either. If it is not dipped, the yard lies



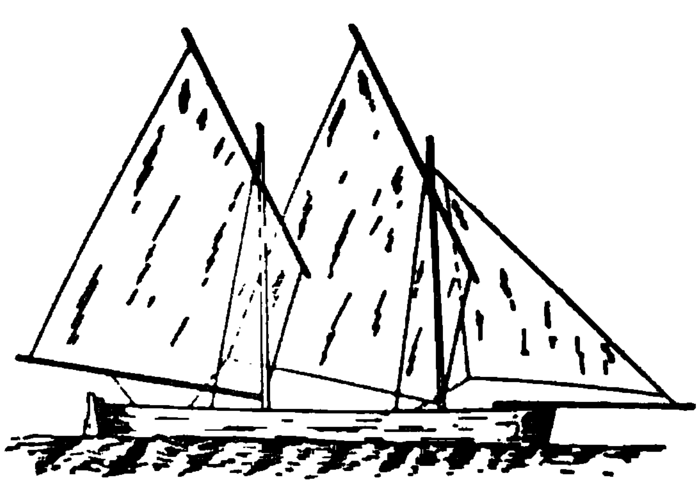
Sliding Gunter
Fig. 1



Low Dipping Lugs
Fig. 2



Balance (French) Lug
Fig. 3



Standing Lug
Fig. 4

RIG OF BOATS FOR SAILING

to windward of the mast on one tack and to leeward on the other. This rig perhaps combines as many points of excellence as any that could be named.

The details of rigging for lug sails vary considerably, but the yard is always attached to the mast by a traveller moving freely up and down. The halyards are usually rove through a sheave in the mast, but sometimes through a block at the mast-head. A down-haul should always be fitted and it is convenient to use for this the bending end of the halyards. As a rule, no shrouds are used, but the halyards are set up to windward and abaft, and serve to support the mast, except in cases where the forward yard-arm dips; in which cases the halyards lead down forward of the mast amidships. The most convenient way to fit the halyards is to use a pendant with a single block at the end, through which a fall is rove.

In the English Navy the larger cutters carry a dipping-lug foresail and a standing-lug mainsail, the latter being replaced in cutters of twenty-seven feet and under, by a mizzen stepped at the extreme stern of the boat with a bumpkin rigged out beyond the stern for the sheet. As the mizzen is of necessity a small sail, the foresail must be large, to give a fair spread of canvas, and being a dipping-lug it is not convenient to handle. In spite of this and the seeming clumsiness of the mizzen, with its boom and bumpkin projecting from the stern, this rig is much liked in the English service. It involves very little gear, and is quickly and easily rigged. The greater part of the sail area, being in a single sail reaching well out to windward and with nothing forward to becalm it, is favorably placed for holding a wind; and boats with this rig sail faster on a wind than those with their canvas divided between a fore and main; but they are at a disadvantage in reaching, and they do not lie-to well. The forward part of the foresail acts as a jib, but with greater pull and smaller leverage; and the absence of a bowsprit is an advantage in going alongside and in plunging into a head sea.

The halyards of a dipping-lug are bent one-third of the length of the yardarm from the forward end. The tack is usually hooked to the stem, except in sailing free, when it is shifted to the weather bow. Some seamen prefer to hook it always to the bow, but the boat will not point quite so high with it there. The most serious danger connected with the lug arises from the fact that if the sail

gets aback, it binds against the mast and cannot be lowered. In this situation, in a fresh breeze, there is serious danger of capsizing. It is a good plan to make the tack fast with a "slip-hitch," which admits of casting it off in an instant, when the sail immediately spills, as it is a characteristic of the lug that its stability depends entirely upon the tack.

The dipping-lug sometimes takes the shape of Fig. 2, Plate 79, which, it will be seen, is an approach to the latteen rig. Here the forward yardarm is the one to be dipped, and the luff is short enough to admit of dipping without lowering the yard. The tack makes fast amidships, a light jigger being used to get it well down. The halyards are led down forward, close in to the mast, and, as in all cases where the halyards are not available for supporting the mast, the mast must be stout and well secured at the partners. Like the French rig already described, this rig, although designed for dipping, will work fairly well as a standing-lug. It is well suited for boats like gigs (old style) which are not built for sailing and have not the stiffness to stand up under a rig whose center of effort is high.

The tack of a standing-lug is made fast to the mast, and the halyards are bent one-fourth of the length of the yardarm from the end. With the balance-lug, the tack may conveniently be fitted to travel across on an iron rod or "horse" just forward of the mast. The point for bending the halyards varies.

The sliding-gunter is one of the safest and most convenient of rigs for boats of small and medium size, but it has comparatively little driving power, particularly on a wind, and for all-around work is distinctly inferior to several of the rigs that have been mentioned above. Sail is reduced in an instant by letting go the halyards, and taken in altogether by tricing up the boom (or clew) as the topmast comes down, brailing up at the same time. This is done as easily with the sails aback as when they are full. On the other hand, the spars are awkward to handle, and still more awkward to stow, since the lower mast, topmast, and sails are usually made up together. This makes it inconvenient to carry the rig in the boat when under oars and impossible to do so if the oars are to be used in rough water. It is a great improvement to make the gunter-irons with clamps so that the top-mast and sail can be stowed separately from the lower mast. A good deal of power is required to step the

masts in shifting from oars to sail, particularly if the boat is rolling.

The halyards of the sliding gunter are bent to the neck of the upper gunter-iron and lead through a sheave in the mast. The clewrope leads from the clew to the proper point on the mast for tricing up the boom snugly.

§ V. HANDLING BOATS UNDER SAIL.

TRIM.—To do her best under sail, a boat must be trimmed in accordance with her build and rig.

If she carries considerable head sail, she will need to be deeper forward than would otherwise be desirable. If she has little or no head sail, she should trim by the stern. The build and rig are fixed upon with reference to each other, due consideration being given to the purpose for which the boat is designed. Once fixed, these characteristics are practically permanent. The *trim* of both boat and sails, on the other hand, can be varied within rather wide limits; but they, too, must be considered with reference to each other. Most boats when on the wind sail best when carrying a little weather helm; that is to say, when they have a slight tendency to come into the wind. Too much weather helm may be corrected by shifting weights aft; too much lee helm, by shifting forward.

The weights should be kept out of the ends of the boat, without being unduly crowded together amidships. It is especially important to keep heavy weights out of the bow. The only ballast, *as such,* that should be carried, is water in breakers. Under no circumstances should "sinking" ballast be allowed; ballast, in other words, which is heavier than water. The lower the weights can be stowed, the better; but care should be taken to keep the *well* clear for baling. Ballast and cargo must be secured against the possibility of shifting. The crew should be kept well down and nobody allowed to stand on the thwarts or to sit on the gunwale. If the men are sitting to windward in a fresh breeze, they should move amidships for passing under the lee of a vessel or other object, where the wind may fail or even shift in an eddy. The mast should be properly stayed, up and down or with a slight rake aft, and the halyards taut up.

In a lug rig, the halyards act as a weather shroud, the tie being

led down to windward and abaft, and set up by a purchase. In most other rigs, shrouds are fitted.

On the wind, as has been said, a boat should carry a little lee rudder.[1] The sails should be kept well full, sheets not too flat, but everything drawing and the boat *alive.* It is a common mistake to get the sheets so flat that the boat, while pointing high, actually makes a course to leeward of that which she would make if kept away a little with sheets eased accordingly; and it is of course clear that if kept away, her speed will be greater than when jammed up into the wind in the hope of stealing a fraction of a point. A boat of good draft with a deep keel or center-board, and yachts designed for racing, with fin-keels hanging ten feet below their normal draft, will lie amazingly close to the wind with little or no leeway. Ship's boats, however, are not constructed on yachting lines and cannot be held up in the same way.

Sheets may be hauled flatter in smooth water than in rough, and the sheets of standing lugs, gaff- and boom-sails, sliding-gunters and the like, may be hauled flatter than those of dipping-lugs. The sails being properly set, the weather cloths of the sails are kept just trembling, with weather helm[1] enough to let the helmsman "feel" that she wants to come into the wind. As the wind will vary more or less (in apparent, if not real, direction), it is necessary to be watchful and to bring her up or keep her away from time to time in order that she may be always at her best. The sails should be kept fuller in rough than smooth water, and it is more important that the boat should be kept *going* so as to be always under command of the rudder. If a heavy breaking sea is seen bearing down upon her, she should be luffed to meet it and kept away again as soon as it has passed. If she loses way she becomes helpless at once. It is dangerous to be caught by a heavy sea on the beam; and if the course to be made in rough water would bring the boat into the trough of it, the best plan is to run off for a time with the sea on the quarter, then bring her up with it on the bow, and so to make good the course desired without actually steering it at any time.

It is a universal rule in boat sailing that the sheets should never be belayed in any weather.

For a moderate squall, the boat should be luffed sufficiently to shake, without spilling, the sail, thus keeping headway enough

1. weather helm.

to retain control, but with the sheet (as always) in hand. If it comes stronger, she must be luffed more decidedly and the sheet slacked more or less. The sheet may of course be let go, and in a sudden emergency this must be done at once in addition to putting down the tiller,[1] and, if necessary, reducing sail; but the longer she can be kept under control the better, and to let go the sheet is to give up control.

The situation is quite different in running free. Here the sail cannot be spilled by a touch of the rudder,[1] and the only prudent thing is to slack the sheet while luffing. The force of the wind would be much reduced by running off, but the trouble with this is that if it comes too strong there is no resource but to lower the sail, and the chances are that it will bind against the shrouds and refuse to come down. Moreover, there is always danger that the wind will shift in the squall, and the mainsail may gybe with dangerous force.

REEFING.

When a boat begins to take in water it is time to reef. And she should never, even in smooth water, be allowed to heel too much. A boat that is decked over may run with her lee rail awash; but when an open boat is approaching this point it must be remembered that a fresher puff may bear the gunwale lower without warning, and that the moment it dips, the boat will almost certainly fill and capsize. The details of reefing will depend upon the rig, but a few general rules may be laid down. The men should be stationed before beginning, and should all be required to remain seated. One hand lowers the halyards as much as may be necessary, another hauls down on the luff and shifts the tack. The sheet is hauled in a little to let the men detailed for the reef points get hold of and gather in the foot. The sheet is then slacked and shifted, the points passed, the halyards manned, the sail hoisted and the sheet trimmed. It is important to keep the boat under command while reefing, and for this she must have way enough to obey her helm.[1] If she can be luffed a little and still kept going through the water sufficiently to obey her helm,[1] then it is unquestionably wise to luff, but not sufficiently to risk losing control by the rudder.[1]

If the boat has more than one sail, it is a good plan to reef them one at a time.

1. helm.

RUNNING BEFORE THE WIND.

This is the most dangerous point of sailing in a fresh breeze because of the chance of gybing. The danger increases if the boat yaws, as she will have a tendency to do if trimmed at all by the head; from which follows the rule, in running, to keep the weights fairly well aft, though never at the extreme after end. Very careful steering is required; and if the sea is really heavy, the chances are that the boom will gybe in spite of all the care that can be taken, unless lashed to the rail or a shroud by a "lazy guy."

Squalls are not so dangerous before the wind as when close-hauled, unless they are accompanied by a shift of wind.

If they call for any reduction of sail, it may be made by dropping the peak of the mainsail (if a gaff sail) or, more satisfactorily, by reefing.

The foresail is sometimes set on the side opposite the mainsail, in running before the wind, a temporary boom being rigged by using a boat-hook or an oar. A boat sailing in this way is going "wing and wing."

If the sea is rough, it is well to avoid running with the wind dead aft. To make a course directly to leeward, the wind may be brought first on one quarter and then on the other, the mainsail being clewed up or the peak dropped each time the course is changed, if the breeze is strong enough to make gybing dangerous.

A serious danger in running before a heavy sea is that of "broaching-to." The boat will yaw considerably, the rudder will be often out of water when it is most needed to meet her, and the sails will be becalmed in the trough of the seas. The situation here is much like that of a boat running in a surf; and, as in that case, the yawing will be reduced by keeping the weights aft and by steering with an oar. The jib should always be set, with the sheet flat aft. It helps to meet and pay her off if she flies to against the helm. A drag towed over the stern is also helpful.

Another danger in running is that the boom may dip as she rolls and thus capsize the boat.

TACKING.

In tacking, the same principles apply to a boat as to a ship. After-sail tends to bring her head to wind, head-sail to keep her

off; but all sails, so long as they draw, give her headway and so add to the steering power of the rudder.[1]

It is clear that a short full boat will turn to windward better than a long and narrow one and will require a much shorter distance for coming round. Thus a short boat is preferable to a long one for working up a narrow channel.

Under ideal conditions, a boat close-hauled but with good way on, shoots up into the wind as the tiller[1] is eased down, making a good reach to windward and filling away on the new tack without for a moment losing headway. The main boom is hauled amidships, and, as the jib and foresail lift, their sheets are let go. The boat comes head to wind and as she pays off on the new tack the sheets are hauled aft and she is steadied on her course. Under less favorable conditions, tacking is not so simple. If there is a sea on the bow advantage must be taken of a smooth time to ease the tiller[1] down; the main boom must be hauled amidships gradually, and the foresail kept full as long as it will draw. If the boat loses headway, the jib sheet is held out on the old lee bow (not too far) to pay her head around, and care must be taken not to make a "back-sail" of the mainsail. As she gathers sternway, the rudder[1] is shifted, and, if necessary, an oar is gotten out to help her around. Carrying the weights forward is favorable for tacking, but when a boat has sternboard she may be helped around by putting a few of the crew on the (new) lee quarter, where, by increasing the immersion of the full lines of the counter, they add to the resistance and cause the bow to fall off.

If she gets "in irons," either an oar must be used or the jib and fore sheets must be hauled over on the old tack, flat aback, to give her stern board. This last is a dangerous maneuver in a strong breeze and rough sea.

The statement is sometimes made that it is *lubberly* to use an oar in a boat under sail. The lubberly part is the getting into a position where an oar is needed. Being in such a position, it is proper to use the oar for getting out.

Attention may again be called to the fact, already mentioned more than once, that in squally weather, a boat is in a dangerous position whenever she is without headway, because she can neither be luffed nor kept away in the event of being struck by a heavy puff. If, through ignorance or carelessness, the sheets are belayed at such a time, the danger is enormously increased.

1. helm.

On July 17, 1902, a sail-boat full of people, in charge of an experienced fisherman, was capsized near the Isles of Shoals, off the coast of New Hampshire, under the following circumstances:

The weather had been stormy, but had moderated. The wind was light but puffy, and there was a rather heavy sea running. The boat had tacked, but had not gathered headway and was lying in the trough of the sea when a squall struck her. The sheets were belayed. The helm was put down, but the boat, having no way, could not answer it. A sudden dash of spray caused the passengers to crowd hastily to leeward, and this, added to the effect of the squall and the sea, capsized the boat. Fourteen lives were lost.

Some years ago a schooner yacht was lying at anchor in New York harbor, with foresail and mainsail set and the sheets belayed to prevent the sails from slatting about. A sudden squall came up, on the beam, and the yacht capsized before she had time to swing.

WEARING.

In wearing, the rudder is put down and the main sheet slacked away roundly The boat goes off before the wind, the mainsail is either gybed or clewed up and shifted over (preferably the latter) and the boat is hauled up on the new tack, losing more or less ground to leeward according to circumstances. The details of the maneuver may vary considerably according to the conditions of wind and sea and the peculiarities of the boat as to rig and trim. In a light breeze, the main sheet is slacked away roundly until the wind is aft, then hauled in smartly for gybing and eased away steadily on the new lee quarter. In a fresh breeze, as gybing would be dangerous, the mainsail is clewed up just before the wind comes aft, and set again in time to bring her to the wind on the new tack; or, in the case of a "cat" or other rig where the head of the mainsail sets on a gaff, the peak is dropped to reduce sail temporarily.

The fore and jib sheets are shifted when nearly before the wind. As she comes to on the new tack, they are left flowing until hauled aft to meet her by the wind.

REMARKS ON GYBING.

A sail is "gybed" when it is allowed to swing from one side to the other, the wind being aft or nearly so, and the sail full first on one side and then on the other. This may be done intentionally, as in wearing or in changing course, or it may come

unexpectedly from a shift of wind or from the yawing of the boat. As it necessarily involves a violent swing of the sail, it puts a heavy strain upon the spars and fittings and causes the boat to lurch more or less deeply to leeward. Moreover, the violent sweep of the boom across the stern endangers everybody in its path.

In a light breeze, these dangers are perhaps not serious enough to justify the rule that a mainsail should never be gybed, but in a fresh breeze it should not be thought of; and the fact that it is often done by experienced boatmen does not make it any more seamanlike.

When a necessary change of course in a fresh breeze will bring a shift of wind from one quarter to the other, the sail should be lowered or clewed up for a moment before putting down the rudder, and then set again on the other quarter. If this cannot be done and it is still necessary to gybe, *the peak should be dropped,* the boom hauled in slowly and eased away on the new tack.

With a sliding-gunter rig the mainsail should be brailed up for gybing.

§ VI. HANDLING A BOAT UNDER OARS.

There is perhaps quite as much art in handling a boat under oars as in handling it under sail, but comparatively little of this art can be taught by precept. There is of late years a tendency in all navies to rely very much upon steamers and motor boats, and as a consequence of this it has become rare to see man-of-war boats handled with the smartness which characterized the best of them not many years ago. Yet the need of just such training as produced this smartness is greater now than ever before, because of the changes which are making of the modern man-of-war's man a mechanic and a soldier rather than a sailor.

In going into a crowded or difficult landing, pull easily and keep the boat under control with the oars as long as possible.

In going through a narrow entrance, get good way on the boat, then trail or toss the oars.

Remember that a loaded boat holds her way much longer than a light one.

In pulling across a current, try to get a *range* of two objects in line and steer by these to avoid being set down by the current.

Having a long pull against the tide, run inshore where the tide is slacker than in midstream.

If the weather is thick or may become so, make sure you have a compass in the boat, and note the course you must make coming and going.

There should always be a lantern, filled and trimmed, in the boat, and boats should never leave the ship for a trip of any great length without a compass. Weather is liable to thicken at any time, and a boat without a compass would have difficulty in reaching a landing or returning to the ship. For this reason, boat-officers and coxswains of running-boats should at all times know the compass course between the ship and landing, and if they are away from the ship and it begins to thicken, they should at once observe the compass course before the ship is shut in, and note the direction and force of wind and current.

If taken in tow by a vessel, make her give you a line instead of taking your painter, and keep this clear for letting go in an instant. If towing astern, hold on with a short line close up under the counter; if towing alongside, have a long line and watch your steering.

Never go alongside a vessel when she has stern way. In a seaway always board a vessel to leeward, unless there is wreckage floating alongside.

(See Chapter " Rescuing the Crew of a Wreck.")

In coming alongside in a seaway or a strong tide, warn the bow oarsmen to look out for the line which will be thrown from the ship.

Caught in a Gale in a Boat.

Rig a sea-anchor by lashing the spars and sails together, the sails loosed. Fit a span to this and ride by the painter. If there is oil in the boat, use a bag of it on the sea-anchor.

Running a Line.

Coil the greater part of the line in the stern sheets, but take end enough in the bow to make fast when you reach the landing.

Pull away and let the ship pay out more line until you are sure of having enough in the boat to reach, then pay out from the boat. Always have plenty of good seizing stuff for making all secure, and if you are to stand by the line, have an axe for cutting if ordered.

If laying out with the tide, take less line in the boat than otherwise; if against the tide it will save work to take all the line in the boat, pull up and make fast, then bring the end back to the ship. With a long line to be laid out in a strong current, it will usually be necessary to have several boats, one to run away with the end, the others to underrun at intervals, floating the line and pulling up stream with the bight.

If the line is to be secured to a post, put a bowline in the end before starting, and throw this over the post. Bend on a heaving line and let the bow man throw this if hands are standing by to take it, or jump ashore with it himself if necessary.

The running of lines is now usually done by a power boat.

Towing.

In ordinary cases of towing—*an unladen boat* in a *smooth sea* —the towing boat passes clear of the oars of the tow (oars of tow should preferably be tossed to facilitate this), placing herself in line ahead, receives painter from the tow, secures it to ring-bolt in stern-post, and starts ahead immediately she has hold of the painter.

The bowman in the tow must not give the towing boat his painter until she is in line ahead; he will then take in the slack of the towline, keeping a strain on it, and gradually pay it out, thus getting way on the tow gradually. This latter precaution is particularly necessary if the tow is at all heavy.

Though it is frequently impracticable, it is always preferable for the towing boat to give the tow a painter (instead of *vice versa*), which the tow should tend and keep ready for letting go in an instant. If this is not done, and the tow gives the towing vessel her bow painter, which is shackled in the bow, a hatchet or sharp knife should be kept at hand for cutting the towline in an emergency.

If the tow is heavily laden, or the sea rough, the above method

brings too much strain on the stem and stern-posts of the boats; hence in such a case the painter should be toggled to a stretcher between the two after thwarts of the towing boat and to the forward thwart of the tow. To steer a boat that is towing in this manner, bear the towline over on the quarter toward which it is desired to turn, for the helm will be of little use.

Towing of ship's boats is now usually done by the steamers, which are frequently fitted with a span the ends of which are secured to either quarter. This facilitates steering and is in all respects preferable to securing the towline to the shackle in the stern-post.

When being towed astern of a large vessel, use a short scope so as to remain close under the counter, with the bow partly out of water. In casting off when there are other boats towing astern, be careful, before letting go, either to drop clear of them all with your towline, or be handy with your oars to avoid getting athwart the hawse of some of them.

Except in the case of unladen boats in smooth water, a number of boats should never be towed tandem by their painters, for in a long tow this brings a considerable strain on stem and stern timbers of the foremost boats. To avoid this strain, the towing vessel should pay out sufficient line to reach the bow of the last boat, the other boats being secured to it by slip-lines at bow and stern.

If towing alongside, have the towline from as far forward on the towing vessel as possible; either toggle it to the forward thwart (steadying it over the stem with a bight of the painter), or pass it through the forward rowlock on the side nearest the towing vessel. Pay particular attention to the steering.

CHAPTER X.

HANDLING BOATS IN A SURF.

§ I. PRELIMINARY.

The handling of boats in a surf is an art in itself, calling for special knowledge and skill such as can be acquired only by practical experience. When undertaken by those who have not this experience, the danger involved can hardly be over-estimated.

Of the various methods of landing on a flat beach which are described in the Rules of the National Life-boat Association quoted below, the safest is probably that of backing in, keeping the bow toward the surf, pulling out to meet each breaker, then backing in as fast and as far as possible *on its back.*

A surf never looks as dangerous when seen from seaward as it really is; and a boat having to land through it, should, if there is a possibility of help from the shore, await such help before attempting to go in. As, however, it is often necessary to attempt a landing where no expert assistance is available, the following rules have been drawn up and published by the Royal National Life-boat Institution of Great Britain:

§ II. RULES PUBLISHED BY THE ROYAL NATIONAL LIFEBOAT INSTITUTION, ON THE MANAGEMENT OF OPEN ROWING BOATS IN A SURF; BEACHING THEM, ETC.

In Rowing to Seaward.

As a general rule, speed must be given to a boat rowing against a heavy surf.

Indeed, under some circumstances, her safety will depend on the utmost possible speed being attained on meeting a sea.

For, if the sea be really heavy, and the wind blowing a hard on-shore gale, it can only be by the utmost exertions of the crew that any headway can be made. The great danger then is, that an

approaching heavy sea may carry the boat away on its front, and turn it broadside on, or up-end it, either effect being immediately fatal. A boat's only chance in such a case, is to obtain such way as shall enable her to pass end-on, through the crest of the sea, and leave it as soon as possible behind her. Of course if there be a rather heavy surf, but no wind, or the wind off shore, and opposed to the surf, as is often the case, a boat might be propelled so rapidly through it, that her bow would fall more suddenly and heavily after topping the sea, than if her way had been checked; and it may therefore only be when the sea is of such magnitude, and the boat of such a character, that there may be chance of the former carrying her back before it, that full speed should be given to her.

It may also happen that, by careful management under such circumstances, a boat may be made to avoid the sea, so that each wave may break ahead of her, which may be the only chance of safety in a small boat; but if the shore be flat, and the broken water extend to a great distance from it, this will often be impossible.

The following general rules for rowing to seaward may therefore be relied on:

1. If sufficient command can be kept over a boat by the skill of those on board her, avoid or "dodge" the sea if possible, so as not to meet it at the moment of its breaking or curling over.

2. Against a head gale and heavy surf, get all possible speed on a boat on the approach of every sea which cannot be avoided.

If more speed can be given to a boat than is sufficient to prevent her being carried back by a surf, her way may be checked on its approach, which will give her an easier passage over it.

On Running before a Broken Sea, or Surf, to the Shore.

The one great danger, when running before a broken sea, is that of *broaching-to.* To that peculiar effect of the sea, so frequently destructive of human life, the utmost attention must be directed.

The cause of a boat's broaching-to, when running before a broken sea or surf, is, that her own motion being in the same direction as that of the sea, whether it be given by the force of oars or sails, or by the force of the sea itself, she opposes no resistance to it, but is carried before it. Thus, if a boat be running with her bow to the shore, and her stern to the sea, the

effect of a surf or roller, on its overtaking her, is to throw up the stern, and as a consequence to depress the bow; if she then has sufficient inertia (which will be proportional to weight) to allow the sea to pass her, she will in succession pass through the descending, the horizontal and the ascending positions, as the crest of the wave passes successively her stern, her midships, and her bow in the reverse order in which the same positions occur to a boat propelled to seaward against a surf. This may be defined as the safe mode of running before a broken sea.

But if a boat, on being overtaken by a heavy surf, has not sufficient inertia to allow it to pass her, the first of the three positions above enumerated alone occurs—her stern is raised high in the air and the wave carries the boat before it on its front or unsafe side, sometimes with frightful velocity, the bow all the time being deeply immersed in the hollow of the sea, where the water, being stationary or comparatively so, offers a resistance, whilst the crest of the sea, having the actual motion which causes it to break, forces onward the stern, or rear end of the boat.

A boat will, in this position, sometimes aided by careful oar-steerage, run a considerable distance until the wave has broken and expended itself. But it will often happen, that if the bow be low, it will be driven under water, when the buoyancy being lost forward, whilst the sea presses on the stern, the boat will be thrown (as it is termed) end-over-end; or if the bow be high, or it be protected, as in most lifeboats, by a bow air-chamber, so that it does not become submerged, that the resistance forward, acting on one bow, will slightly turn the boat's head, and the force of the surf being transferred to the opposite quarter, she will in a moment be turned round broadside by the sea and be thrown by it on her beam-ends, or altogether capsized. It is in this manner that most boats are upset in a surf, especially on flat coasts, and in this way many lives are annually lost amongst merchant seamen when attempting to land, after being compelled to desert their vessels.

Hence it follows that the management of a boat, when landing through a heavy surf, must, as far as possible, be assimilated to that when proceeding to seaward against one, at least so far as to stop her progress shoreward at the moment of being overtaken by a heavy sea, and thus enabling it to pass her. There are different ways of effecting this object:

1. By turning a boat's head to the sea before entering the broken water, and then backing in stern foremost, pulling a few strokes ahead to meet each heavy sea, and then again backing astern. If a sea be really heavy, and a boat small, this plan will be generally the safest, as a boat can be kept more under command when the full force of the oars can be used against a heavy surf, than by backing them only.

2. If rowing to shore with the stern to seaward, by backing all the oars on the approach of a heavy sea, and rowing ahead again as soon as it has passed to the bow of the boat, thus rowing in on the back of the wave; or, as is practised in some lifeboats, placing the after-oarsmen with their faces forward, and making them row back at each sea on its approach.

3. If rowed in bow foremost, by towing astern a pig of ballast or large stone, or a large basket, or canvas bag termed a "drogue" or drag, made for the purpose, the object of each being to hold the boat's stern back, and to prevent her being turned broadside to the sea or broaching-to.

Drogues are in common use by the boatmen on the Norfolk coast; they are conical-shaped bags of about the same form and proportionate length and breadth as a candle extinguisher, about two feet wide at the mouth and four and a half feet long. They are towed with the mouth foremost by a stout rope, a small line, termed a tripping line, being fast to the apex or pointed end. When towed with the mouth foremost, they fill with water, and offer a considerable resistance, thereby holding back the stern; by letting go the stouter rope and retaining the smaller line, their position is reversed, when they collapse, and can be readily hauled into the boat.

Drogues are chiefly used in sailing-boats, when they both serve to check a boat's way and to keep her end on to the sea. They are, however, a great source of safety in rowing-boats, and the rowing lifeboats of the National Lifeboat Institution are now all provided with them.

A boat's sail bent to a yard, and towed astern loosed, the yard being attached to a line capable of being veered, hauled or let go, will act in some measure as a drogue, and will tend much to break the force of the sea immediately astern of the boat.

Heavy weights should be kept out of the extreme ends of a boat; but when rowing before a heavy sea the best trim is deepest by the stern, which prevents the stern being readily thrown on one side by the sea.

A boat should be steered by an oar over the stern, or on one quarter when running before a sea, as the rudder will then at times be of no use. If the rudder be shipped, it should be kept amidships on a sea breaking over the stern.

The following general rules may therefore be depended on when running before, or attempting to land, through a heavy surf or broken water:

1. As far as possible avoid each sea by placing the boat where the sea will break ahead or astern of her.

2. If the sea be very heavy, or if the boat be very small, and especially if she have a square stern, bring her bow round to seaward and back her in, rowing ahead against each heavy surf that cannot be avoided sufficiently to allow it to pass the boat.

3. If it be considered safe to proceed to the shore bow foremost, back the oars against each sea on its approach, so as to stop the boat's way through the water as far as possible, and if there is a drogue, or any other instrument in the boat that may be used as one, tow it astern to aid in keeping the boat end-on to the sea, which is the chief object in view.

4. Bring the principal weights in the boat towards the end that is to seaward, but not to the extreme end.

5. If a boat, worked by both sails and oars, be running under sail for the land through a heavy sea, her crew should, under all circumstances, unless the beach be quite steep, take down her masts and sails before entering the broken water, and take her to land under oars alone, as above described.

If she has sails only, her sails should be much reduced, a half-lowered foresail or other small head-sail being sufficient.

Beaching or Landing through a Surf.

The running before a surf or broken sea, and the beaching or landing of a boat, are two distinct operations; the management of boats, as above recommended, has exclusive reference to running before a surf where the shore is so flat that the broken water extends to some distance from the beach. Thus on a very steep beach, the first heavy fall of broken water will be on the beach itself, whilst on some very flat shores there will be broken water as far as the eye can reach, sometimes extending to even four or five miles from the land. The outermost line of broken water, on a flat shore, where the waves break in three or four fathoms water, is the heaviest, and therefore the most dangerous, and

when it has been passed through in safety, the danger lessens as the water shoals, until, on nearing the land, its force is spent and its power harmless. As the character of the sea is quite different on steep and flat shores, so is the customary management of boats on landing different in the two situations. On the flat shore, whether a boat be run or backed in, she is kept straight before or end to the sea until she is fairly aground, when each surf takes her further in as it overtakes her, aided by the crew, who will then generally jump out to lighten her, and drag her in by her sides. As above stated, sail will, in this case, have been previously taken in if set, and the boat will have been rowed or backed in by oars alone.

On the other hand, on the *steep* beach, it is the general practice, in a boat of any size, to retain speed right on to the beach, and in the act of landing, whether under oars or sail, to turn the boat's bow half round towards the direction from which the surf is running, so that she may be thrown on her broadside up the beach, when abundance of help is usually at hand to haul her as quickly as possible out of the reach of the sea. In such situations, we believe, it is nowhere the practice to back a boat in stern foremost under oars, but to row in under full speed as above described.

§ III. NOTES ON THE MANAGEMENT OF BOATS IN A SURF.[1]

From the ship a mile or two off shore, the surf may seem uniform, with no sign of a choice for making a landing. Looking at the backs of the breakers, as to leeward over the waves at sea, gives an inadequate idea of their height and abruptness. In fact, what appears to be a mere swash on the beach, may involve much danger to a carelessly handled or deeply-laden boat. Careful study will often give hints of important differences in the nature of the coast.

There may be stretches of sand beach backed by trees, the lights and shadows of which, according to their relative distances, indicate low-lying points, shallow bays, sand-choked river mouths, or even the lateral entrance of a lagoon into which the ship herself may safely pass. There may be bluffs, below which doubtless lie rocks, sometimes only shown in the churned-up surf

[1] By Lieutenant A. A. Ackerman, United States Navy.

when dangerously near. There is often a current along the shore, and this should be studied before attempting to land. Sometimes its direction changes with the tide; again it is of the nature and perhaps part of an ocean current flowing constantly in one direction. Where there are cliffs, their débris is often swept into the form of an irregular breakwater towards the lee side. This shoal, being of varying height and lacking continuity, may be of little help when covered by high water, but at low water it sometimes affords all the lee required to make an easy landing.

Narrow cañons in long stretches of bluffs, or pockets in a rocky coast, sometimes mark quiet spots; the swell flowing in through deep water and breaking directly on the beach. Such places should as a rule be avoided until carefully studied. It may be possible to make use of them to land behind detached rocks or pass behind the breakers of the adjacent bluffs, but there are always sunken rocks to be feared; and the fall of the tide, or the setting in of a heavier swell, may suddenly turn the smooth seas at the entrance into heavy breakers.

A single rock, hardly far enough off shore to be shown on the chart as separated from the beach, will frequently have a quiet place in its lee, although the approach to it may at times be dangerous.

It is more difficult to choose a landing on a long stretch of sand beach; but wherever a shoal appears, or the surf stretches far out, a comparatively light surf, and perhaps even a smooth way in, should be looked for on the lee side.

Confused surf off the mouth of a lagoon or river, or the slanting breakers which sometimes run along the beach, as a rule indicate strong currents. When these are understood, a handy boat may sometimes dodge the breakers and work into smooth water with surprising ease. There is always danger, however, that the stranger may be swept down into heavy surf, or while heading up against the current or main breakers, have the boat filled by cross-seas.

Often a number of the heaviest swells follow each other in succession, after which there is a short and comparatively mild interval. Such a recurrence of quiet spells, as well as the point at which the swells become dangerous by commencing to break, and that at which they fall into harmless confusion, should be watched for and taken advantage of in landing.

The number of lines of breakers or width of surf does not always determine the difficulty of landing, as the outer lines will be much the heaviest; and if these can be avoided or passed without shipping too much water, the others will probably not be dangerous to a well-handled boat. Notice should always be taken before entering the surf, especially where it is wide, of the probable drift of the boat. It may be set by the current down among rocks or into heavy breakers.

The beach, too, may present obstacles to a safe landing, apart from the surf. At high water, it may break directly on a steep shingle beach which would be difficult to climb, even without being obliged to drag the boat clear of the breakers. If assistance could be had from on shore, such a beach might be charged on the back of a breaker and the boat hauled up clear before the next one filled it. Working with the crew alone, however, the depth of water and poor foothold would usually prevent any but the most active crew in a light boat from landing without being swamped. At the same point, an easy landing might be made on the sloping sand beach below the shingle by waiting an hour or two for lower water.

Before entering the surf at a strange locality, it is well to lie off it for awhile, noting its peculiarities and accustoming the crew to them. Dangerous breakers may form and pass, but the quieter intervals are very encouraging.

Speaking generally, a very light and buoyant boat, with a crew of as small a number as possible to handle it, will pass in and out through moderate surf with ease, while a heavy ship's boat with a powerful crew would at least take on board considerable water. Beyond a certain point, the added strength of a man does not begin to compensate for the increased weight. The requirements of a good surf-boat differ materially from those of a deep-sea life-boat, yet they are alike in some particulars. The difference lies mainly in the fact that the latter is designed to ride in a rough sea, which, since the boat rises and falls with it, does not have the battering force of a breaker. The surf-boat, on the other hand, perhaps while lying dead in the water, or carried out by oars and undertow, must meet and pierce or surmount a wall of water advancing with great velocity.

A very light and broad-beamed, single-banked, six-oared whale-boat is perhaps the type of ship's boat in which the best

proportion of power to resistance and weight moved is likely to be obtained.

If time permits, a towing-post should be fitted in the bow for veering the surf-line and this may be suddenly required to take great strain when the boat is struck by a breaker.

Besides possessing the buoyancy due to lightness of material, it would be a great advantage for the boat to be fitted with light air-tanks filling all unoccupied space and so reducing to a minimum the capacity for shipping and holding water. In fact, an extreme type of surf-boat would somewhat resemble the Esquimo's kayak, in which the boat has a cover, the only opening of which is gathered tightly around the occupant's waist.

Great *sheer* is important, and the upper strakes should flare somewhat at bow and stern to prevent their dipping under when the opposite end of the boat is lifted high on the side of a breaker. The flare of upper strakes, however, should not amount to such bluffness as will increase resistance to cutting through the crest of a wave. To permit the boat to rise and fall quickly in response to the swell, weights should be kept out of the extreme ends.

The underwater body of the boat should offer as little lateral resistance as possible to the water. Should she, in pulling out to meet a breaker, be inclined slightly from the normal and be carried back, however little, her keel, rudder-post and run would be resisted and retarded by the dead water on the front of the breaker, while the bow would be swept rapidly around turning the boat more and more broadside on, until the gunwale dips and it finally rolls over. The coxswain must in such a case attempt to pry the stern around with his steering-oar and the crew make every effort to get way on the boat and surmount the breaker before the turning action has culminated in a capsize. If the bottom of the boat is rounded and smoothed off in every direction, the water has very little hold either for turning it against the leverage of the steering-oar, or to roll the boat over should it broach-to. In fact, a light dory has been known to be swept broadside on for a long distance before a breaker without capsizing. The smooth bottom offered so little resistance to the dead water on the shore side of the breaker that there was very little tendency to trip the boat up.

High freeboard, high roomy thwarts and favorable positions for oarsmen and coxswain to exert their strength, are all important qualities. The modern navy whale-boat is a great im-

provement over the old one in these respects. It is, however, necessarily a compromise; and with very little alteration it could be greatly improved for passing the surf. Its propelling power should be nearly equally spaced about the center of buoyancy, which may be accomplished by placing an additional thwart in the stern sheets and leaving the forward thwart vacant. Passengers should sit on the bottom of the boat between thwarts; all unnecessary weights and gear should be removed. The coxswain should have a grating lashed over the stern sheet benches to give him a good foothold. Swivel rowlocks should be used; there is great danger of fouling the oars in the surf and it would then be very difficult to free one from an inserted rowlock before it had caused the boat to broach-to. Stretchers and boat-breakers should be lashed down and all other unnecessary gear dispensed with.

The subject of oars merits consideration. The steering-oar should be broad, stiff and not too long. Its exact length depends upon the boat and the height of the coxswain's platform; eighteen feet may be regarded ordinarily as a good length. A longer oar may be used to advantage at sea and its need may be felt at times in the surf; for example, when the stern is raised on the crest of a breaker and the blade of the oar barely reaches the water in the trough. On the other hand, when the boat is in a dangerous position and being carried back, a long oar is worse than useless, as it is almost impossible to keep its blade from catching in the dead water, where it tends to turn her broadside on. The other oars should also be light and stiff to permit easy handling and quick application of power. On troubled water, either at sea or in the surf, oars which exceed a certain length dependent upon the beam and freeboard of the boat are a nuisance. They cannot be handled quickly, wear the men out and are certain to strike on the back stroke or foul each other. If, in addition, they are springy, by the time the power is well applied in one direction, the boat may be turned or tilted and most of the stroke lost. No hard and fast rule can be given for the length of oars; that had better be determined by actual test in each particular boat. It will seldom, if ever, however, be found advisable to employ in a single banked boat, an oar longer than twice the beam at the thwart plus the freeboard at the oarlock.

Whichever way of landing is adopted, a conical drag, towed ten to twenty fathoms astern, will be of great assistance. It

should have a tripping line to invert it when it is not required to check the boat. Too much reliance should not be placed upon the drag, however, for though it will always *assist* to keep the boat pointed fair to the breakers when the line is hauled in briskly by a couple of men, there is not the positive assurance of holding the boat that is given by a surf-line attached to a well-bedded anchor planted outside the surf.

There are occasions when the use of such a surf-line and anchor is invaluable. Among them may be noted the landing in a large or unwieldly boat; landing with a weak or inexperienced crew, or in high surf where it is necessary to return, or in any case where it seems pretty certain that the crew will be unable to maintain control over the boat with their oars. On the other hand there are certain disadvantages connected with the use of the surf-line. There is a current along almost every beach and if the surf is wide, a boat going out may drift down so far that when the dangerous breakers are reached, the line to the anchor leads broad off the bow and tends to turn the boat rather than steady it head-on to the breakers. Should a boat using a surf-line be capsized in the outer surf, the coils of line will probably knot and tangle so as to prevent the boat from drifting in.

Whenever the line is used, a hatchet should be kept close to the bowman's hand with which to cut the line should it become necessary. In going in where the surf is wide or there is a current, the line may be used to pass the outer breakers and then abandoned. If a bucket is tied to the end, it may be picked up again and used on going out. The anchor should be buoyed with spare oars or other gear so as to recover it should the boat be obliged to abandon the line or to cut it in coming out.

All unnecessary articles are taken out of the boat. The water-breaker is tightly plugged and lashed down, as are the stretchers and buckets for bailing. The men shift into light clothes without shoes. If the weather is sufficiently cold to require it, dry clothing may be carried in the air-tanks, which should, however, be carefully inspected and all unnecessary articles removed. A hatchet, copper tacks, sheet lead, and roll of felting should also be carried for use in case the boat is stove. If the beach is distant, it may be possible to go under sail, or to be towed by another boat so as to keep the men fresh. The presence of a second boat would also be of great assistance, if it was used to distribute oil over the water abreast

the landing, for although the quieting effect of oil is much less marked upon a surf than upon deep sea waves, there is abundant evidence that its value is considerable, especially in the comparatively deep water where the outer and most dangerous breakers form.

A second boat lying outside would be an encouragement to a crew pulling out from shore, and might be of great assistance to the probably exhausted men after their trip through the breakers.

In going out, the time of start, though important, is less so than when coming in, as it may be possible to pull half-way out without taking water on board or meeting dangerous surf. If a surf-line is used, take the boat up the beach until it appears that when carried down by the current and hauled out at the same time it will reach the dangerous space with the line fair to the anchor. Station two active, powerful men to haul in the line, as more progress will be made in this way than if they took oars. The four after-oarsmen steady the boat, standing in the water opposite their thwarts, oars apeak. Put the passengers aboard, haul taut the line, and commence walking out the boat, the coxswain at the stern. As soon as the boat leaves the bottom the men climb in and take their oars, pointing them to prevent drift until ready to start. The intention is to so time the arrival of the boat at the outer line that no heavy breakers will be met at that point. Varying width of surf and speed of boat may make this difficult of attainment.

At the start the men, pulling and hauling, force the boat rapidly through the water. Irregular waves splash into the boat; later they become too large to be pulled through without taking much water on board. It is then best to check headway, tauten the line, and peak oars as the breaker passes. So the boat works out, obviously passing many more breakers than when coming in. Gradually the filling boat becomes sluggish, difficult to pull and steer. In this condition it may be capsized if only slightly turned, and it may now be better to go back, bail out, and try again, than to struggle on and risk an almost certain capsize in the heavier breakers.

A properly pointed boat may succeed in passing through a breaker that it cannot hope to ride. The water may fill it to the thwarts, in which condition it will capsize at a touch, but once clear of the breakers it may be bailed out and enabled to meet the waves of any ordinary sea in safety.

CHAPTER XI.

GROUND TACKLE.

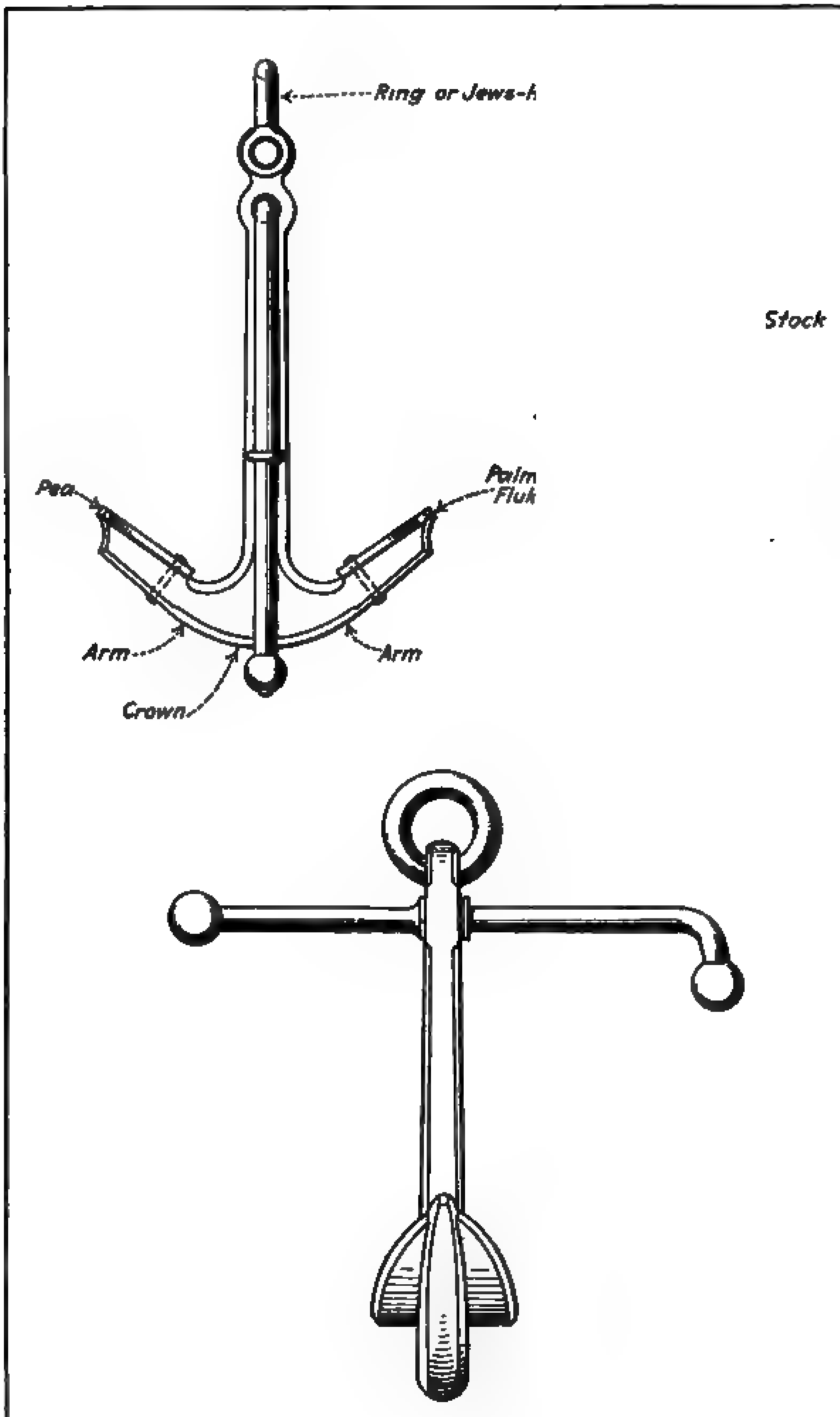
§ I. ANCHORS.

The form of anchor commonly used throughout the world from the beginning of the last century up to about 1875 was, in most essentials, that shown in Plate **80.** It is true that double-fluked anchors resembling those now so familiar were proposed as early as 1850, but they were slow in making their way, and it was not until about the year above-named that they began to come into anything like general use. They are now almost universally used by steamers, and the prejudice which long existed against them in the minds of seamen is rapidly dying out.

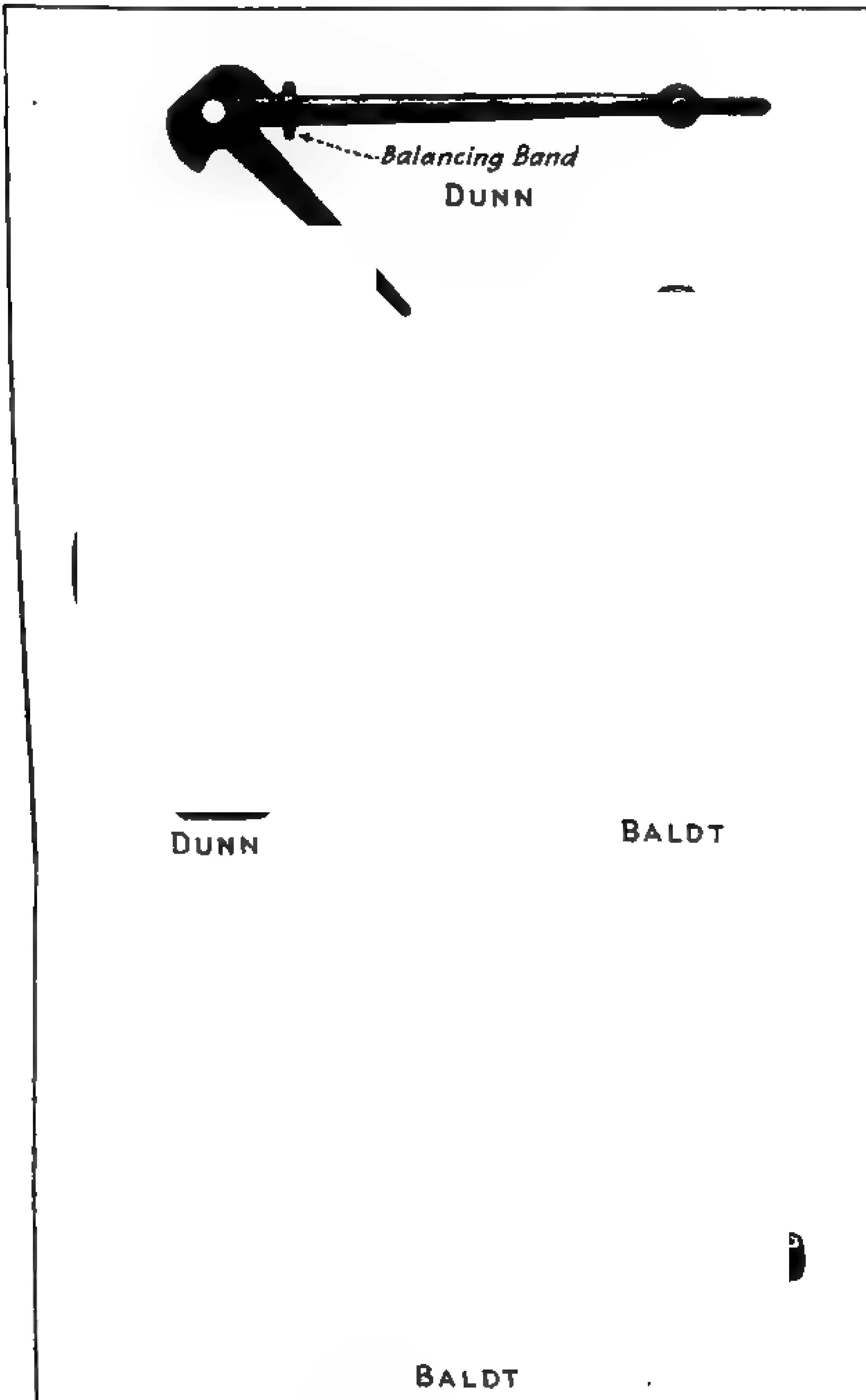
When an old-fashioned anchor is let go in water fairly deep, it strikes the bottom crown first, and immediately falls over until it rests on the end of the stock, the arms lying horizontally. From this position any drag of the chain to one side capsizes or "cants" it, pulling the stock down horizontally upon the bottom and pointing one of the flukes fair for biting. As the drag continues, the fluke is forced into the ground, and if the anchor is well designed, the heavier the pull the deeper the fluke goes down —provided sufficient length of chain is given to keep the pull approximately parallel to the bottom. For this reason, quite as much as because of the "cantenary" that comes from a long scope, it is important to use plenty of chain, particularly when the anchor is taking the first hold. In good holding ground, anchors frequently bury themselves completely. This tendency of the old-fashioned anchor to work into the ground under a pull is one of its most valuable characteristics, and one not possessed by any of the "double-fluked" types, using this term to designate the general type in which the two flukes are in the same plane and act together in holding.

The principal advantages of the double-fluked type are, first, an enormous gain in convenience of handling and stowing, and second a freedom from danger that the ship may ground on some part of the anchor when swinging over it in shallow water.

Plate No. 80.



OLD FASHIONED ANCHOR.



PATENT ANCHORS.

The anchor shown in Plate **80**, represents fairly well the most approved design of the old type. The palm is of medium size, the arms shaped to the angles most favorable for biting, and the cross-section of each part carefully designed for maximum strength in the direction of the strain to which it will be subjected. All edges are chamfered off to reduce the wearing of the chain as its bight rides over the anchor, and all re-entering angles are rounded as much as possible.

This type is nearly obsolete and within a few years will probably have disappeared altogether. At present its use is confined to sailing ships and to small steamers and motor boats, except that in the Navy it is retained on some of the older cruisers and gunboats which are themselves rapidly becoming obsolete.

Plates **81** and **82** show several of the best known types of double-fluked anchors. The following features are common to them all.

1st. The arms are pivoted upon the shank and can swing from thirty to forty degrees on either side.

2nd. The palms are in the plane of the arms instead of at right angles to it.

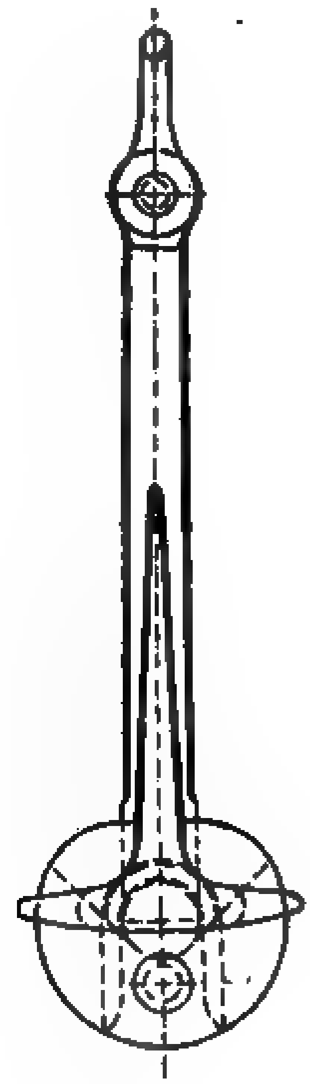
3rd. It results from this construction that both flukes should bite if either one does.

4th. To insure that the flukes shall bite, the arms carry, at the crown, a projecting shoulder with a sharp edge, which takes on the bottom and throws the arms downward.

The anchors principally used in the Navy are the *Dunn* and *Baldt*. Others sometimes used in the Navy and very frequently used in the American Merchant Service are the *Allison, Eels* and *National.*

It may be laid down as a rule that the patent anchor always needs a longer scope of chain to bite and hold than does the old-fashioned one. This is because a slight upward pull on the ring drives the old-fashioned fluke into the ground but breaks out the flukes of the other type.

Anchors are usually made of cast steel, recent improvements in the manufacture of that metal having made it sufficiently reliable to justify its employment for this purpose. But the stocks, rings, pins, shackles, balancing bands and other fittings should in all cases be forged, and in the case of housing anchors, the shanks also.



PATENT ANCHORS.

In ships of the early design, anchors were stowed on a bed (technically a "bill-board") built on the bow of the ship a little distance abaft the hawse-pipe, where they were secured as in Plates 83 and 84. Anchors designed to be stowed in this way are fitted with a "Balancing-band" on the shank (Plate 81, Fig. 1) and are handled by a purchase or a pendant from a heavy iron davit, shown in Plate 83. This davit turns about a vertical axis, plumbing the proper point of the bill-board at one part of its train and swinging out well clear of the bow at another part. In men-of-war it is hinged to turn down flat upon the deck, out of the way of gun-fire.

At the davit head may be hooked either a heavy single block, swivelled and carrying a pendant, or the upper block of a heavy purchase, usually three-fold.

Where a pendant is used, it leads down to a block at the heel of the davit and then aft. In some cases a thimble is turned in the end and a deck tackle hooked to this, the fall going to a capstan or a winch; in others, the pendant is taken direct to the capstan, the length being such that there are several turns around the barrel when the pendant is hooked and set taut ready for surging chain.

If a pendant is used, it may be either chain or wire. The latter is to be preferred, and for several reasons. It works more smoothly on the barrel of the capstan, and is better adapted, by its elasticity, to stand the sudden jerks which are unavoidable in stowing anchors. For a given size of sheave, a stronger pendant may be used of wire than of chain; and a flaw in wire can be seen at once, whereas in chain it can never be detected until it gives away.

At its outer end the pendant carries a large hook which is hooked to the balancing-band when the anchor is hove up to the hawse-pipe. The pendant having been set taut, the winch is started, the chain veered, and the anchor swings to the pendant and is run up and landed on the bill-board and secured as in Plate 84. To let go, the releasing-bar to which the ends of the stoppers are secured, is tripped, allowing the anchor to slide off of the sloping bill-board.

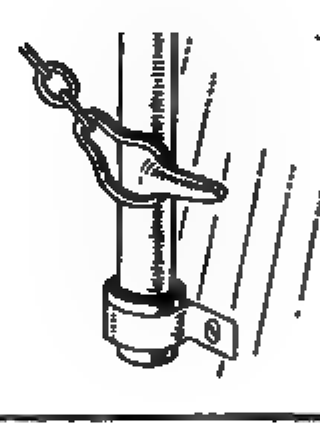
Plate 83 shows a patent anchor stowed in this way and Plate 84 an old-fashioned anchor. Plate 83 shows also a patent anchor with the shank housed in the hawse-pipe with the flukes lying

Plate No. 83.

BOW OF U. S. S. DELAWARE, SHOWING ANCHOR STORAGE.

Plate No. 84.

Stowing the Bower Anchor of a Battleship.



Releasing Bar, Enlarged.

DETAILS OF ANCHOR STORAGE ON BOAT.

against the side plating. If designed to be stowed in this way an anchor must be very strong in the shank to stand the strain which comes from canting over the lip of the hawse pipe as it is dragged inside. The strain is especially serious in men-of-war of recent date, in which the hawse pipes are made almost horizontal with a view to getting the anchor, when housed, so high above the water that it will not drive a cloud of spray on board when the bow is pitching into a head sea. This strain, although a maximum on the shank, which has to bear the leverage of lifting the flukes, is very great also on all other parts of the ground tackle, including the windlass.

In very recent battleships, a third hawse-pipe is fitted at the stem (Plate 85). This not only provides a third anchor available for immediate use but makes it possible for the ship to ride with her stem true to the tide or wind, thus doing away with the annoying and often dangerous yawing which is common where the riding chain leads from a hawse pipe at a considerable distance abaft the stem.

Men-of-War usually carry the following anchors:

Three **Bower Anchors,** one of which may be called a "Sheet Anchor" as a convenient method of identifying it. The bower anchors of the Massachusetts and Lexington classes will weigh 24,000 lbs.

One **Stream Anchor** of approximately one third the weight of a bower. This is often carried astern.

Three or more **Kedges,** the heaviest of which may weigh a ton.

Boat Anchors, as required.

A Sheet Anchor was formerly an anchor heavier than the bowers, kept in reserve for an emergency. The term has now no significance except as a matter of convenience, the anchors being designated as: "Starboard Bower," "Port Bower," "Sheet."

A Stream Anchor, in days when men-of-war were frequently called upon to navigate rivers, was carried at the stern (originally) for use on occasions when it became necessary to drop an anchor astern to avoid swinging to the current or for any other reason. Later the term came to mean an anchor of medium weight, wherever stowed and for whatever purpose used. In this sense, the designation is conveniently retained.

Any anchor carried at the stern is conveniently designated as a "Stern Anchor," without reference to its weight, or purpose; as a boat carried on the quarter is called a "quarter boat."

Plate No. 85.

BOW OF U. S. S. IDAHO.

§ II. CHAIN-CABLES AND APPENDAGES.

MATERIAL. Until very recently all chain-cables for ships were made of wrought-iron. Experiments had from time to time been made with steel, in some cases with promising results; but even where greatly increased tensile strength was in evidence, there remained a suspicion in the minds of seamen that the increase in strength had been purchased by a sacrifice of the trustworthiness that had long been associated with the *ductility* of wrought-iron.

It is doubtless true that when wrought-iron and steel are of approximately equal strength the ductility of the iron gives it an advantage for many purposes, and especially for chain cables—first because the absence of brittleness makes it safer under the shocks to which cables are often subjected, and again because the elongation before rupture which results from ductility serves as a warning of overstrain. In cases, however, where the tensile strength of steel is greatly in excess of that of wrought-iron, it is clear that the gain in strength may much more than offset the loss in ductility. It happens, moreover, that certain important factors other than strength and ductility enter into the efficiency of a cable, and that several of these are more easily secured in steel, and especially in cast steel, than in iron. Among these may be mentioned uniformity of size and shape and resistance to deformation, ensuring a good fit on the lugs of the windlass wild-cat.

The first attempts to manufacture chain-cables of steel were necessarily made with mild steel because high carbon steel does not weld securely, and the only process available for large chains involved leaving each link open until it could be threaded through the link which preceded it, and then welding the ends of the new link together. Moreover, it was felt, as has been explained above, that the quality of ductility, which is common to both wrought-iron and mild steel, was essential. Recent improvements in the characteristics of steel and in the methods of casting, added to the exigencies of the World War, have resulted in the development of a *cast-steel* chain-cable which has 40 per cent. greater strength than the best wrought-iron. This chain can be cast complete in any desired length; but the following process is found more convenient:

One half of the links for a complete length of chain are cast separately and allowed to cool. These are to form the odd-numbered links of the chain. They are ranged in a row in mould cavities, with intervening spaces left for the even numbered links. Patterns representing the missing links are threaded through the finished links and a continuous mould constructed by means of which the missing links are cast in their proper places, the result being a complete and continuous chain of interthreaded links. Plate **91**.

This chain, of "Naco" cast steel, has been approved by the British and American "Lloyds" and is coming into very general use in the Merchant Service. It has been subjected to severe tests by the Bureau of Construction of the Navy Department and issued to a number of battleships for test under service conditions. In tests made at the Boston Navy Yard the average breaking load of 2¾ inch "Naco" chain was found to be 700,000 pounds as against 506,000 pounds for the best wrought-iron.

As a result of these tests, it has been decided that the future standard chain-cable of the United States Navy of 2 inches and above shall be of cast steel, except the shackles and swivels, which are to be drop-forged of a special grade of steel having a high tensile and elastic strength combined with good ductility. As these parts (shackles and swivels) are not subject to limitations either of casting or of welding, it is possible to use a steel which will give almost any combination of characteristics which may be desired.

SIZE OF CHAIN. Chain is designated as to size by the diameter of the iron of which the common links are made; standard sizes running by sixteenths of an inch from ¼ inch to 3½ inches, this last being the size issued to the largest battleships of the United States Navy.

LENGTHS OF CHAIN. Chain is manufactured in comparatively short lengths, known as "shots." The standard length of an ordinary shot in the United States Navy is 15 fathoms. In the present Naval practice, the first or outboard shot is of approximately 5 fathoms, and the second of 40 fathoms, the object of this arrangement being to prevent the possibility of having a shackle on the windlass while breaking out the anchor. The 5-fathom shot is ⅛ inch larger, and its two outer links from ¼ of an inch to a full inch larger, than the other parts of the cable,

this having been found necessary to provide for the shock to which this part of the cable is subjected in letting go.

As a result of the adoption of the *new type Navy Shackle* described below, and illustrated in Plate 87, it is probable that a uniform length of 15 fathoms will ultimately be adopted for all shots in new cables, except that the 5-fathom shot at the bending end may be retained as a matter of convenience for bending and unbending, and followed by a 10 fathom length; these two together making a shot of 15 fathoms to correspond with the rest of the cable.

SHACKLES. (Plate 86.) In present practice, the shots of chain are joined by "connecting shackles," the bowed end of the shackle being always placed forward (toward the anchor). This helps it to engage the ribs of the windlass wild-cat and prevents it from catching on the controller and hawse-pipe as it runs out.

The bolt of the shackle is sometimes round, but more often oval in section. In the latest United States Naval practice it is egg-shaped. This shape gives an increased bearing surface for a given cross-sectional area, and also makes it impossible to put the bolt in the wrong way—an important consideration in handling ground-tackle at night. The bolt is held in place by a forelock pin driven in a hole through the bolt and the enlarged ends of the shackle. This forelock pin is sometimes of wood—preferably hickory—well coated with white lead and driven home tightly. For unshackling, these pins are either backed out, or sheared by a smart tap of a hammer on the end of a bolt. A better practice is to use a forelock pin of steel, which should be tinned to prevent corrosion. A common practice for securing the forelock pin is to jam it at each end by a pellet of soft lead upset into the hole in the shackle.

The practice in the United States Navy is to use a forelock pin made of steel, tinned, and held in place by a keying ring of lead, which is upset, by a special tool, into a groove around the end of the forelock pin, the other end of this pin having a countersunk head. Plate 90 shows the details of the bolt and pin. In unshackling, the key ring is sheared. To admit of slipping the shackle into place, the end link of each shot of chain is made without studs.

Shackles should go to the capstan flat, so that the strain is taken equally on the two sides with no tendency to open the

FIG. 1. CONNECTING SHACKLE

FIG. 2.
CONNECTING SHACKLE

FIG. 3. BENDING SHACKLE

FIG. 4. BENDING SHACKLE

DETAILS OF GROUND TACKLE.

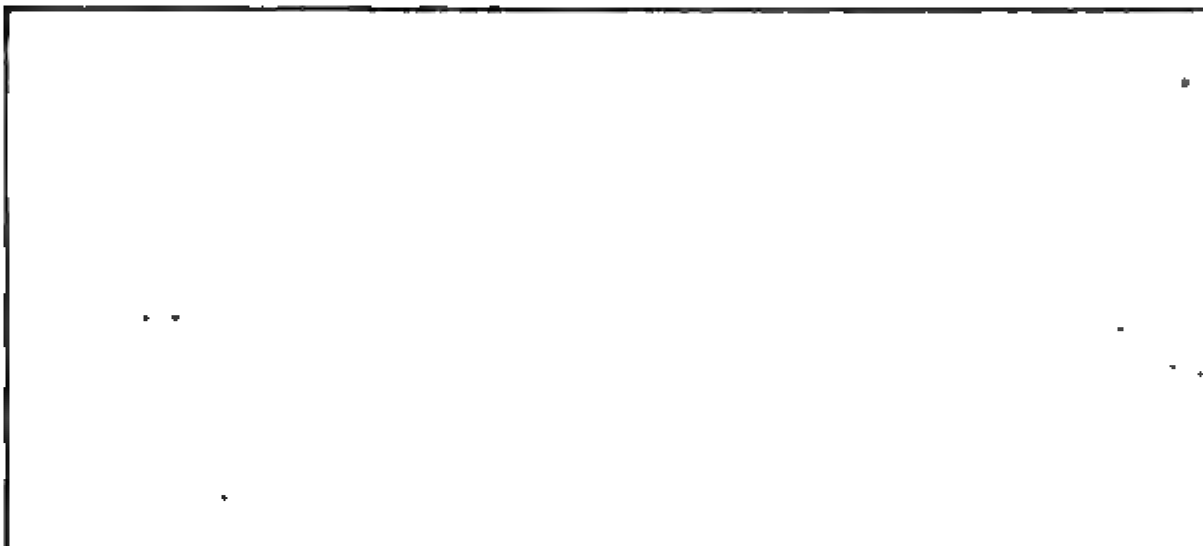


FIG.1. ASSEMBLED

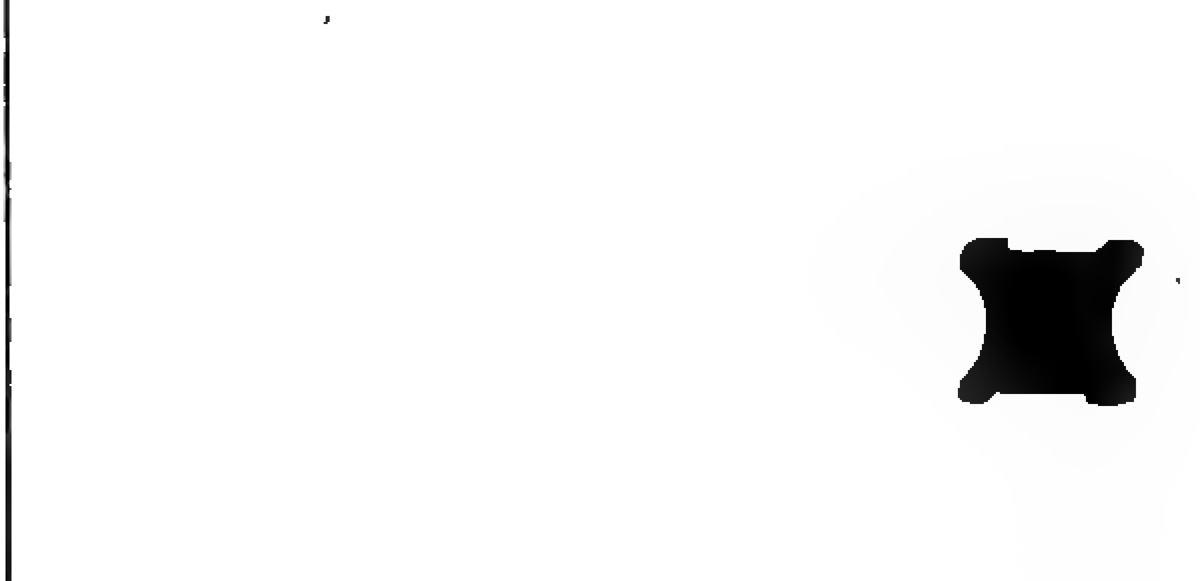


FIG. 2. PARTIALLY ASSEMBLED

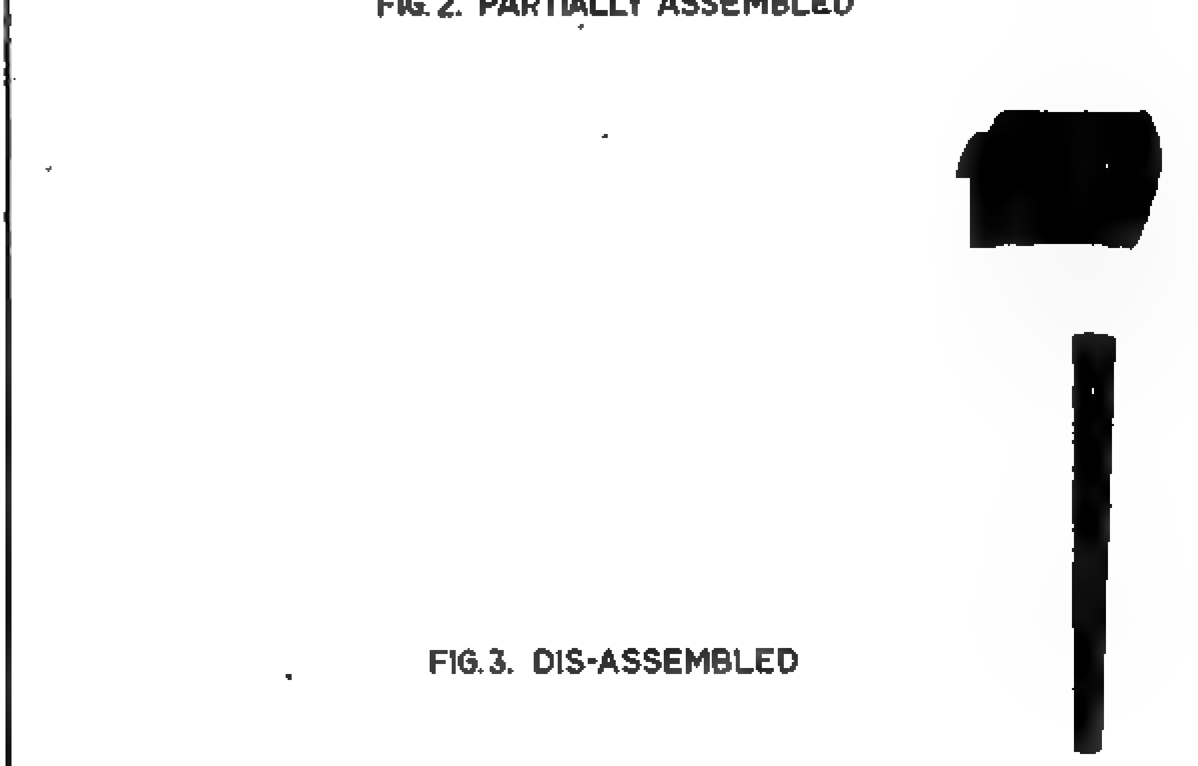


FIG. 3. DIS-ASSEMBLED

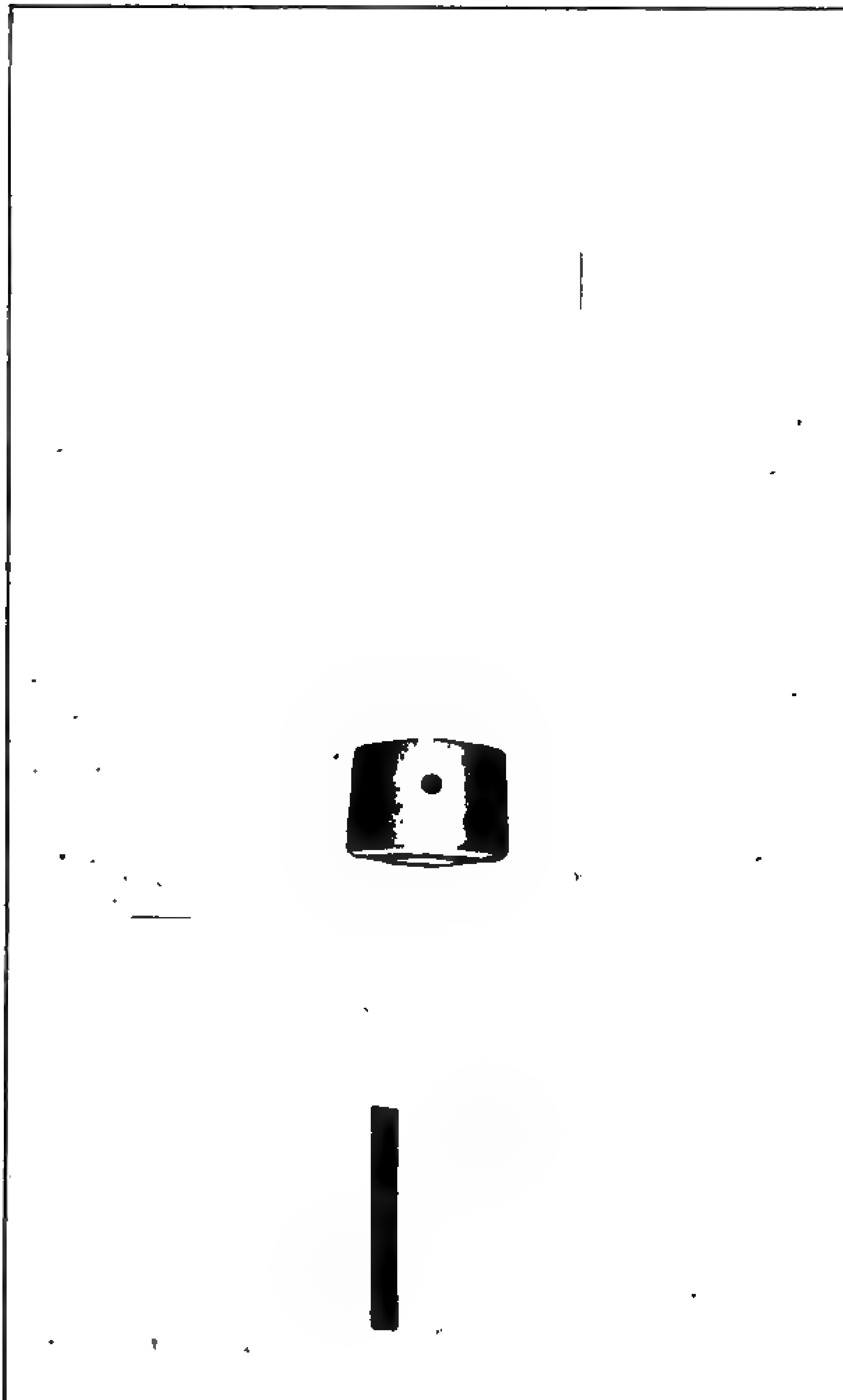
NAVY STANDARD KENTER SHACKLE.

shackle. The eye of the shackle has been designed so that it is stronger than the round.

NEW TYPE NAVY SHACKLE. It is desirable for many reasons to have a shackle which shall correspond in external shape and size with the links of the chain to which it belongs. Plate 87 shows the new "Navy Standard Kenter Shackle" which fulfils these conditions, and has been adopted for use in the United States Navy. With this shackle all difficulties resulting from an imperfect fit on the wildcat will disappear, and the cables of a ship can be made up of uniform shots of any length desired. The frequent accidents to bending shackles, due to fracture or to the opening of the sides as they pass over the lip of the housing hawse-pipe will be much reduced if not entirely eliminated. It is found that the new shackle can be assembled and disassembled as quickly and conveniently as the older type, and can be given the full strength of the standard links.

A very interesting suggestion has recently been made, which, if it proves practicable, will revolutionize the manufacture and character of chain-cables. It is proposed to *build up* every alternate link into a construction closely imitating the new shackle which has been described; the remaining links to be dropped forged of the same grade of steel that is used for the shackles and swivels. In this construction every second link would be in effect a shackle, and the links would be connected up exactly as the shots are now connected. Here again we should get away from the limitations of welding (as in wrought iron chain) and of casting (as in cast steel chain) and could secure practically any desired combination of strength, ductility and other characteristics. In the absence of service tests, which would necessarily be prolonged and should be widely varied, there is some doubt as to the trustworthiness of a chain in which half of the links are built up of several parts connected by mechanical methods. If this doubt is ultimately removed, it will be possible to manufacture chain of at least double the strength of the wrought-iron cable which has heretofore been the standard of the seafaring world.

BENDING SHACKLES. The cable is bent to the ring of the anchor by a bending shackle, similar to the connecting shackles used between the lengths of chain, but somewhat larger and differing in the method of securing the bolt. (Plate 86.) It



SWIVEL.

will be noted, by reference to the official drawing of chain cables, Plate 91, that whereas all connecting shackles are placed with the bowed end forward, the bending shackle is placed with the bowed end aft. The reason for this is that the bending shackle never comes to the wildcat and that it is never in danger of catching on anything as it runs out. On the other hand, it is subjected to its greatest stress in passing over the lip of the hawse-pipe as it is hauled inside for housing, and it will pass over more smoothly if its bowed end is aft. It is found, also, that the tendency of the shackle to *open* as it passes over the lip is much less with the bowed end aft.

The new "Navy Standard Kenter Shackle" (Plate 87), has been authorized for *Bending Shackles* as well as for *Connecting Shackles.*

SWIVELS. To prevent the accumulation of turns as the ship swings about her anchor, swivels are used (Plate 88). Formerly there was one of these in every length of chain, but they gave much trouble in passing around the capstan (being too large to take the sprockets), and their number has been gradually reduced until now not more than three or four are used in the cable, and in United States Naval practice only one is used, this being placed in the first (5-fathom) shot.

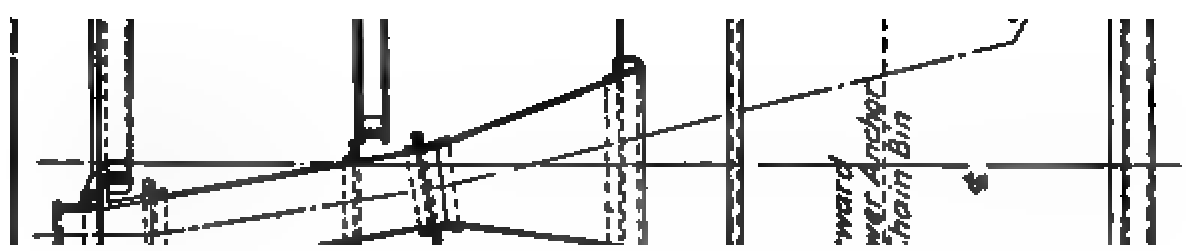
LENGTH OF A CABLE.[1] The total length of a cable may be anywhere from 90 to 200 fathoms. In the United States Navy the standard length has long been 120 fathoms, but this has recently been increased for battleships and large cruisers to 150 fathoms, and for the bower cables of the latest Dreadnaughts to 180 fathoms.

STOWAGE. The cables are stowed in "chain lockers" which are usually in the hold, below the windlass. The inner, or "bitter" end of the cable is first of all rove through a ring in the lower part of the locker and brought up and shackled to a beam or other accessible place by a sliphook or some other arrangement which, while holding securely, shall admit of easy slipping, or of bending on an additional length.

The chain is stowed, as it is paid below, by "tierers," with the aid of chain-hooks, hook-ropes and, in the case of heavy chains, of tackles hooked in eye bolts in the deck above the chain-locker.

[1] A "Cable's Length" as a unit of measurement is always 100 fathoms, this being 8 shots of 12½ fathoms each, the standard length of a shot in the British Navy.

Plate No. 89.



CHAIN LOCKERS.

This operation of "tiering" the cable is of very great importance as the cable if paid down rapidly and stowed carelessly is likely to kink in running out and may jam in the chain pipe, with very disastrous results. It should be stowed regularly and symmetrically in long flakes fore and aft, without kinks.

Watchfulness must be observed to make sure that no one is in the locker when the anchor is let go or the chain veered, and that no gear of any kind is in the way.

The cables of the largest men-of-war are too heavy and cumbersome to be handled by tierers. They are accordingly stowed in deep and very narrow lockers, where there is little chance of kinking, and tierers may be dispensed with. (Plate **89.**) A reliable man should, however, be stationed at the locker both in heaving in and in letting go, to make sure that all goes clear.

STOPPERS (Plate **90**), of which there are many different forms, are used to hold the chains when the anchor is down, to relieve the strain on the windlass, and for securing the anchors and cables at other times. For the largest ships they are of chain, with slip-hooks for holding the cable, and are hooked or shackled to heavy ring-bolts on the deck. When fitted in this way they are known as "slip-stoppers." In smaller ships they are sometimes of rope, usually hemp, with a "stopper-knot" or an iron toggle in the outer end and a lanyard for lashing to the cable.

SLIP-STOPPERS, in addition to their use for holding the cable when riding at anchor, are used with "housing anchors" for *securing* the anchors in their housed positions in the hawse-pipe. When used in this way the stopper usually has a screw turnbuckle for drawing the anchor close up into the hawse-pipe. In this case it is called a "screw-stopper," or "housing-stopper."

In large ships, with housing anchors, the anchor is usually let go from the slip-stopper by knocking off the link of the slip-hook.

MAKE-UP OF CABLE. The make-up of a chain cable for the United States Navy is as follows (Plate **91**):

Beginning with the outboard, or anchor end:

(a) Bending shackle.

(b) First shot of cable, five fathoms in length, of material ⅛ inch larger than that used in other lengths of the cable, with a swivel near the inner end. The three outer links of this length

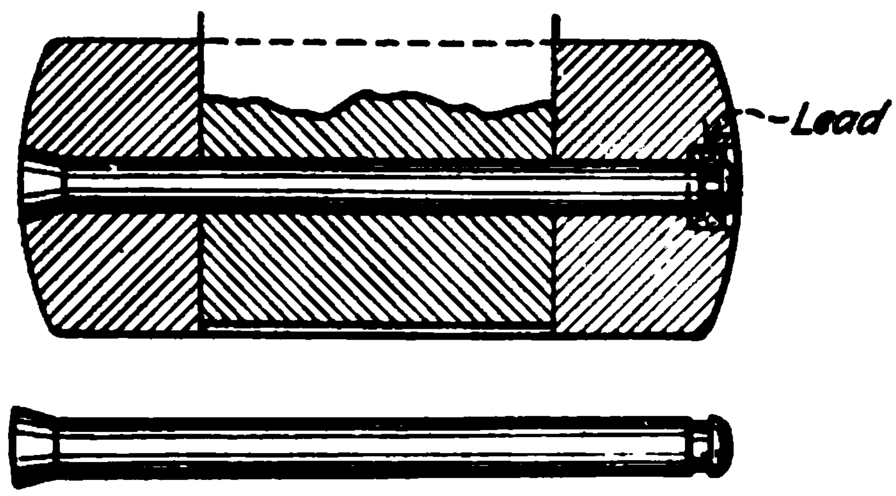


FIG. 1.
DETAILS OF FORELOCK PIN AND LEAD KEYING RING FOR SHACKLES

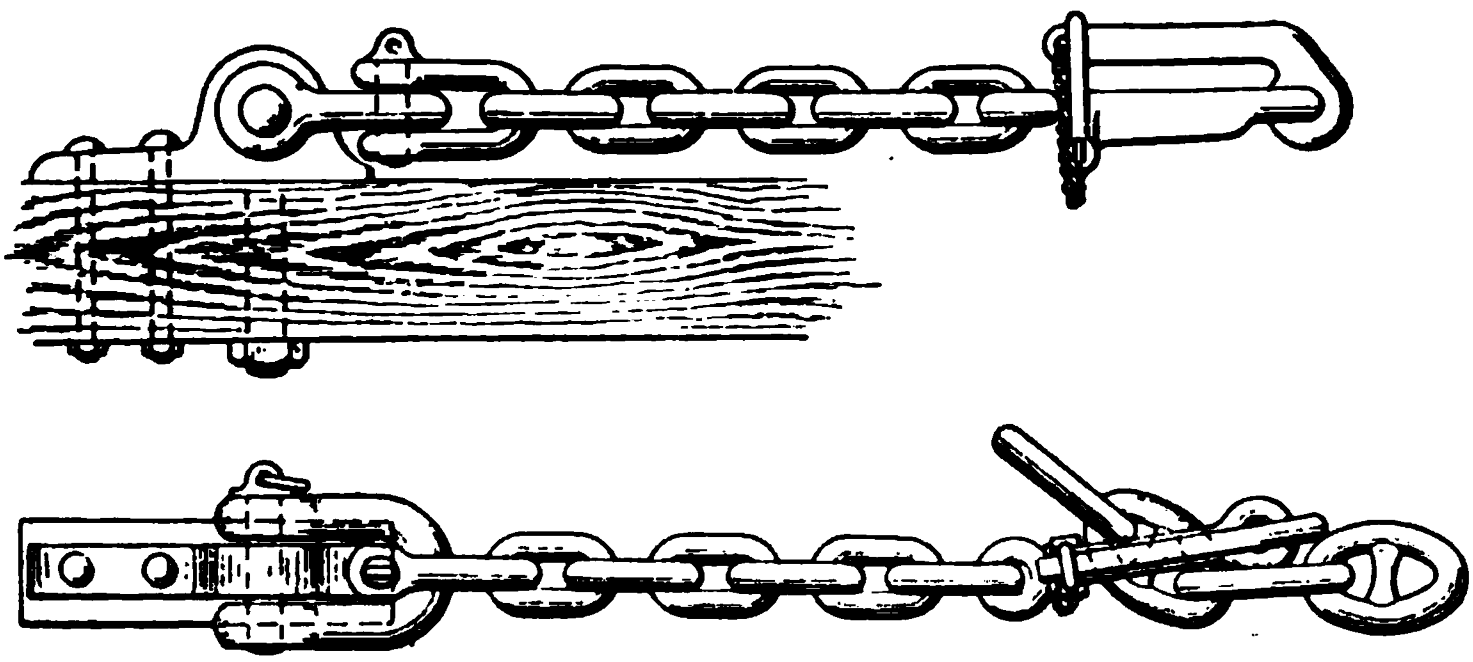


FIG. 2. SLIP STOPPER

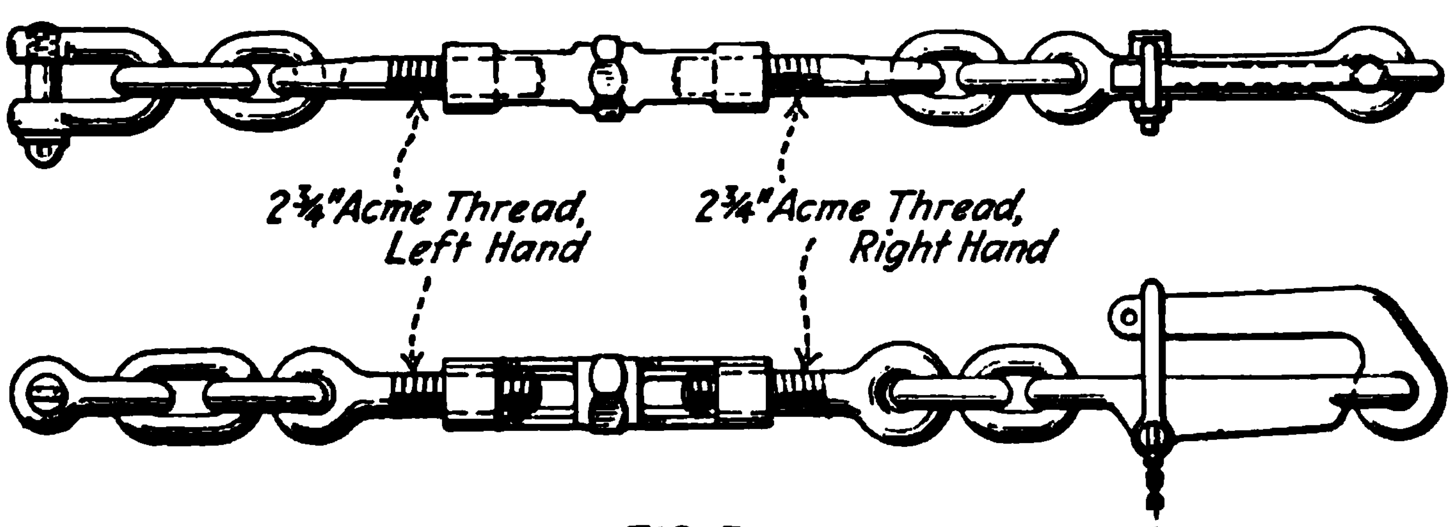


FIG. 3.
HOUSING CHAIN STOPPER, U. S. NAVY.

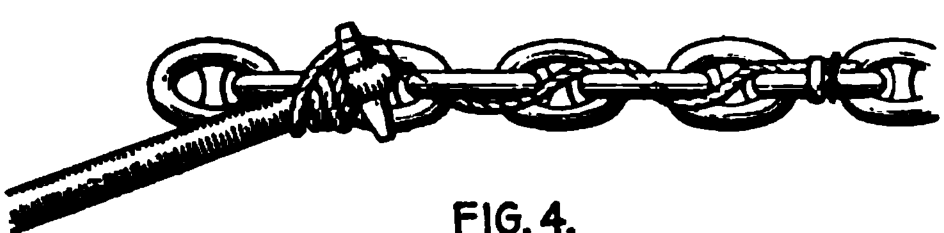
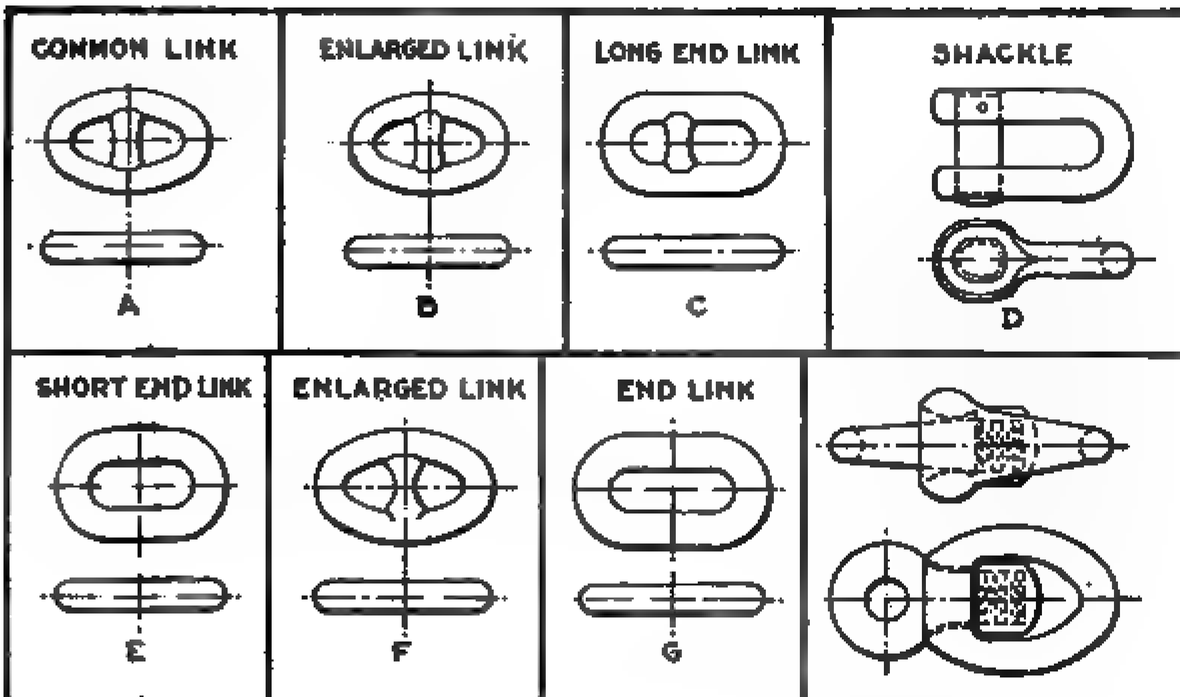
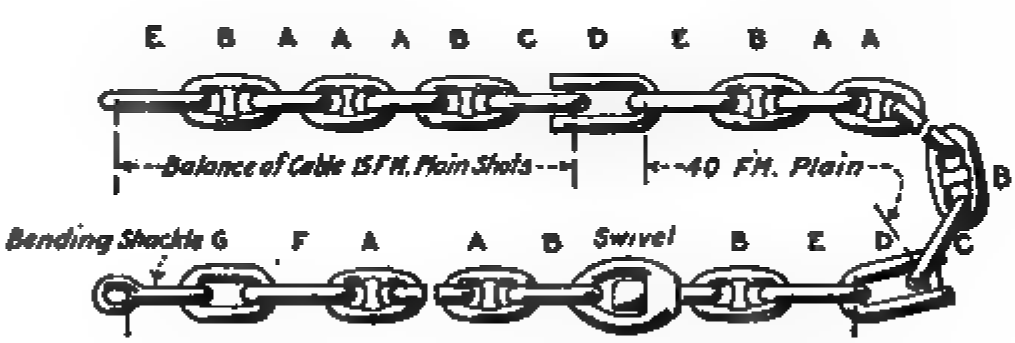


FIG. 4.
DECK STOPPER, (ROPE)

STOPPERS.

Plate No. 91.





MAKE-UP OF CABLES

MOULD FOR CAST-STEEL CHAIN

are larger than the others by an amount varying with the size of the cable.

(c) Second shot of cable, of forty fathoms, connected with (b) by a shackle.

(d) Other shots of cable, each of fifteen fathoms, in number sufficient to make up a total length of 120, 135, 150, or 180 fathoms, and connected by shackles.

The arrangement of the first two shots, of five and forty fathoms respectively, prevents danger of having either a swivel or a shackle on the windlass during the heavy heaving connected with breaking ground.

The use of 150 or 180 fathoms on each of the bower cables makes it practicable to moor with 60 fathoms on each cable, and this is the length now commonly used in mooring.

In handling the anchors, bending and unbending chain, etc., the five-fathom length which comes next to the anchor is usually not unbent, as it is easier to work with the end of this than with the ring of the anchor direct.

WEIGHT OF CHAIN.

Diameter of Material	Weight per Fathom	Diameter of Material.	Weight per Fathom.
Inches	*Lbs.*	*Inches*	*Lbs*
$\frac{1}{4}$	$3\frac{1}{2}$	2	240
$\frac{1}{2}$	15	$2\frac{1}{4}$	300
$\frac{3}{4}$	34	$2\frac{1}{2}$	360
1	58	$2\frac{3}{4}$	440
$1\frac{1}{4}$	90	3	500
$1\frac{1}{2}$	130	$3\frac{1}{2}$	680
$1\frac{3}{4}$	180.		

Marking Cables. Cables are marked by turns of wire on the studs of certain links, the number of the link, counting studded links only, from the shackle on each side, indicating the length. Thus at the end of the first length from the anchor there is *one* turn of wire on the stud of the *first* studded link from the shackle on each side; at the end of the second length, *two* turns on the *second* studded link, etc.

In United States Naval practice, the turns of wire as above described are usually supplemented by painting one or more links with some light color, usually white. The paint shows up well at night and can often be seen at some distance below water. While the practice varies on different ships, the following is a common and convenient system:

At 15 fms.	(No shackle), 1 white link.	
" 30 "	" 2 " links.	
" 45 "	3rd studded link each side of shackle, *white*. Studs of painted links wrapped with 3 turns of wire.	
" 60 "	4th studded link each side of shackle, *white*. Studs of painted links wrapped with 4 turns of wire.	
" 75 "	5th studded link each side of shackle, *white*. Studs of painted links wrapped with 5 turns of wire, etc.	

In weighing, as the chain is hove in, the painted links are wiped dry and re-painted.

Overhauling a Cable. Cables should be overhauled frequently, the chain being roused up on deck, and each shackle, link, and swivel carefully examined. Flaws may be detected by the ring of the metal when struck with a hammer. A defective shackle may be easily replaced by a spare one, but a bad link condemns the whole length of chain in which it occurs—except that a missing stud may be replaced without much difficulty. Every length should be unshackled, and shackle bolts and pins cleaned and coated with white lead and tallow. If a pin is found rusted in, the rust may be cut with turpentine, or the pin broken. Swivels should be well oiled, and worked until they turn freely and without grinding. All marks should be verified, and renewed if necessary.

Perhaps the most favorable of all opportunities for overhauling the cables is when a ship is in drydock. Here the anchor and cables may be lowered into the dock, where they can be handled much more easily than on the forecastle.

The cable having been thoroughly overhauled and the chain-lockers cleaned and painted, the bitter end is made fast, and the chain is paid below and carefully stowed.

Extract from United States Navy Regulations.

"On all vessels the Commanding Officer will have made at least once a year a careful examination of the bower and sheet chains throughout their entire length. They will be ranged on deck by shots, cleaned,

scaled and inspected for defects, shackle and forelock pins refitted and greased or white leaded, and identification marks restored if necessary.

The chain will then be carefully painted. As the shots nearest the lockers are the least used, one of them, or two in the case of battleships and cruisers, providing the shots are in good condition, should be shifted at these times to a position inboard of the 40 fathom shot, in order to distribute the wear more uniformly along the entire length of the chain. If serious defects are discovered they should be brought to the attention of the Bureau of Construction and Repair, and if it is not practicable to make immediate replacement, the defective shots should be shifted to the bitter end of the cable. A note of this examination should be entered on the next following quarterly report."

Not all officers are aware that every shot of navy chain bears upon the side of its forward link a serial identifying number and the year of manufacture.

One of the most frequent and serious accidents to which cables are subject is the springing of a shackle by a strain tending to open out the end.

Such a strain may come from a bad fit on the windlass in heavy heaving, or from the accident of the shackle being subjected to a heavy stress while lying across the outer lip of the hawse-pipe. A pin may be broken in some such way as this, and the bolt loosened, without the injury becoming apparent on casual inspection.

It is a good rule to have not only every shackle but every link examined each time the anchor is weighed. If time does not admit of a careful examination of the individual links, these may be struck with a hammer. The sound will tell if any flaw exists. Time can always be found to look carefully over the shackles.

§ III. HANDLING GROUND TACKLE.

WINDLASSES. There is a great variety in the windlasses used for handling anchors and cables in modern steamers, almost every firm of shipbuilders having a type of its own. Certain general features, however, are common to them all. A steam-engine or electric motor turns a shaft, either horizontal or vertical, on which is mounted a "wildcat," or "chain-grab," over which the chain passes and by which its links are engaged. The wildcat turns loosely on the shaft, but may be rigidly secured to it by some form of connection, and much of the individuality of different types of windlasses lies in the nature of this connection. The wildcat is secured to the shaft for heaving the chain in or out, but is disconnected in veering chain and in riding by the

windlass; being controlled, when so disconnected, by a friction brake.

Plate 92 shows the electric windlass to be installed in the new battleships and battle cruisers of the North Carolina and Lexington classes, and Plate 93 the steam windlass for the latest type of Destroyers. Plate 94 shows an earlier type of windlass (horizontal) carried by some of the older battleships which are still in service. The drawings have been prepared with a view to illustrating the details of interior mechanism, especially the arangements for locking and unlocking the wildcats.

Directions for Keeping Windlass in Order.

Keep all the bearings well oiled. Oil holes and automatic lubricators are provided for all the bearings. They should be kept free from dirt and regularly inspected. Use none but the best sperm oil for bearings. A mixture of equal parts of black lead and tallow makes the best preparation for the worm-wheel and worm to prevent cutting and wear.

The windlass should never be run without the gear teeth and worm being well slushed with black lead and tallow, a can of which is sent with every machine, and which should be replaced with more of the same material.

When the windlass is not in use, the cylinders and steam-chest drips should be left open, so as to drain all the condensed steam from the engines.

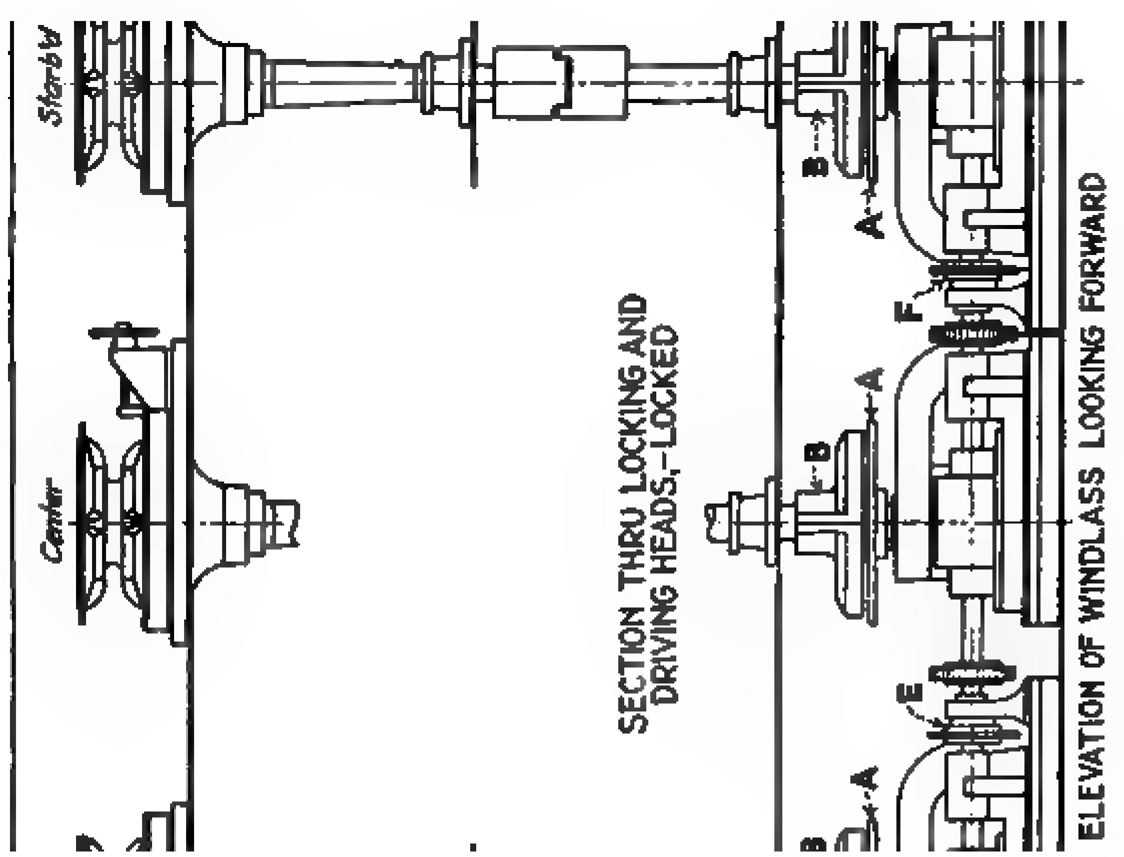
When starting a windlass for the first time it should be handled carefully and under the direction of an experienced person. Run it at first without any load till the bearings and worm and worm-gear teeth are perfectly lubricated.

LETTING GO. In modern ships with heavy ground tackle, the anchors are commonly housed in the hawse pipe and secured by slip-stoppers which engage the chain by a slip or "Pelican" hook. (Plate 90.) In preparing to let go, all but one of these stoppers are cast off and the windlass brake slacked, leaving the anchor hanging by one slip-stopper immediately abaft the hawse-pipe.

If the drift between the hawse-pipe and the chain-locker is considerable, it is well to rouse up a few links of chain, lighting the slack forward to a point just abaft the stopper.

Care must be taken that all is clear below decks and in the chain-locker. A reliable man should be stationed near the locker and made responsible for this.

To let go, the link of the slip-stopper is knocked loose with a sledge.



BATTLESHIP'S WINDLASS

Plate No. 93.

DESTROYER'S WINDLASS.

WINDLASS ON OLDER BATTLESHIPS.

As the anchor may hang in spite of the slack links above mentioned, it is well to have an anchor-bar at hand for shaking up the chain, especially if anchoring in formation when a delay of a few seconds may be serious.

Where the anchor is carried on a bill-board, as in Plate 84, the lashings used in securing the anchor for sea must first of all be cast off, leaving the anchor hanging by two chains, each secured at one end by a lashing and at the other by a link which engages a trigger-bar, by tripping which both chains are released simultaneously.

In some cases anchors carried on a bill-board are lifted by a "fish-tackle" hooked to a swinging davit and lowered until they hang by the cable from the hawse-pipe, from which position they are let go from a slip-stopper exactly like the housing anchors already described.

The anchor should always be let go with the ship moving slowly, either ahead or astern, to avoid paying the cable down on top of the anchor.

With the old-fashioned anchor, it is generally better to be going astern, at least when anchoring head to tide or wind, as otherwise the bight of the chain is likely to foul the anchor as the ship drops back. If conditions are not such that she will drop back over the anchor, this point is of no consequence; and with a patent anchor (which has no projecting fluke to be fouled) it is not important in any case. There are some advantages about letting go with headway on, especially when it is desired to anchor at a definite point—standing in, for example, on a given bearing and anchoring when another bearing is on. It is much easier to do this with the ship going ahead and thus under control; and no other way is practicable if it happens that the line on which we run in is more or less across the wind or tide.

In case of a number of vessels anchoring together in formation, it is essential that all should let go while going ahead with some speed, and it becomes a matter of considerable interest to know what speed is safe under these conditions. It will be found that almost any ship with reciprocating engines or electric drive, running at a speed of four or five knots with steam available for twelve knots, and backing with full power as the anchor is let go, can be brought up at 45 fathoms without undue strain on the cable. With turbine engines even this speed is too high be-

cause of the limited power available for backing. Here the maximum permissible speed is believed to be not in excess of three knots.

If obliged to let go at a higher speed, or if for any reason it does not seem safe to check her with so short a scope, *the chain should be allowed to run until she loses her way sufficiently to make it safe to snub her.* There is no great harm in running out 75 or even 90 fathoms of chain and afterward heaving in to a shorter scope; and it should be remembered that even in cases where the headway has to be checked by bringing up on the chain, the danger is less with a long scope than with a short one, for the same reason that makes a long scope safer in riding to the anchor.

> The danger connected with letting go while under considerable headway is often overlooked, for the reason that *the damage resulting from it does not necessarily show itself at once.* The excessive strain may distort and weaken the links of the cable, without actually parting them. The result is that the cables may give way at some future time under a comparatively moderate stress. In the British Navy it was long the custom to let go with considerable headway, especially in mooring; but in October, 1908, an order was issued by the Admiralty forbidding this practice and stating that experience has shown that the parting of cables in H. M. ships has been due mainly to the gradual weakening to which they are subjected by anchoring and mooring with too much way on.

It is a general practice for ships approaching an anchorage to slow to half or two-thirds speed when some distance from the point for letting go and later to stop their engines and let the speed drop as it may, the actual speed at which the ship is moving when the anchor is let go being a matter of guess-work within rather wide limits. It would seem more reasonable to slow to the speed which is considered safe for letting go, while far enough from the anchorage to be sure of settling down to this speed (as definitely fixed by the number of revolutions) by the time the anchorage is reached, and to stop the engines as the anchor is let go. This is especially advisable where ships in squadron are anchoring together, as it not only fixes definitely the conditions

for anchoring but makes it far easier for the ships to keep their distance from each other. (See Chapter on "Keeping Station and Manœuvring in Squadron.")

Where it becomes necessary to anchor in very deep water, it is absolutely essential that the ship should be going dead slow. If several ships are anchoring in formation, they should anchor in succession, not simultaneously. As the anchorage is approached, at very slow speed, the anchor may be lowered gradually until it is within a few fathoms of the bottom, and then let go, only enough headway being maintained to avoid paying the chain down on top of the anchor. The details of handling the windlass for anchoring in this way will vary with the type of windlass used, but it will be found that even where the ship is dead in the water, and where the anchor is let go with only a few fathoms of drop, *the weight of the chain alone will cause it to run out very violently.* In extreme cases, where the depths run, as in Puget Sound ports for example, up to 40 and 50 fathoms, it is advisable not to "let go" at all, but to "back out" the chain by the windlass engine, until the anchor is on the bottom and the necessary scope of chain out.

While the danger of fouling the anchor by paying the chain down on top of it is not as serious in the case of a patent anchor as in one of the old type, it is much better to avoid this if practicable, by having a little way on the ship at the instant of actually placing the anchor. The sooner the way can be checked after this instant, the better.

WEIGHING. In heaving in, the windlass and the cable may be relieved by a judicious use of engines and the helm, and the officer on the bridge should be kept informed of the direction in which the chain "tends" or "grows" on the bow, and whether it is taut or slack. Report is also made when the chain is "up and down" from the ring of the anchor to the hawse-pipe and when the anchor is "a-weigh"; that is to say, when it has been broken out from the bottom.

In a ship with a ram bow, the chain will sometimes get across the ram. It may be cleared by stopping the windlass and going astern a few turns with the proper engine.

If there is much tension on the chain when a shackle or swivel comes to the wildcat, there will be trouble from the slipping of the chain, as swivels and shackles are necessarily larger and

longer than the links, and cannot take the lugs of the chain-grab so securely. This trouble may always be expected when the depth of water is such that a swivel or a shackle is on the wildcat in breaking ground or after the anchor is aweigh. It may be met by clapping a "hook-rope" on the cable at once and taking this to the "gypsey" or the capstan. If neither of these is convenient, a deck tackle may be hooked on and well manned. If the drift between the windlass and the locker admits of such a thing, a tackle abaft and below the wildcat is very helpful, tending not so much to relieve the stress as to jam the chain down into its place on the wildcat, and so to prevent slipping. In ships where this difficulty is to be anticipated, it should be prepared for as part of the regular preparations for getting underway.

Shackles and swivels, with the links adjoining them, are, in cables of standard manufacture, made of lengths and sizes carefully proportioned to the rest of the chain and to the cable-holders with which they are to be used. Improvements in this direction and in the design of the cable-holders have greatly reduced the difficulties described above. In cables like the latest ones for the United States Navy, where there is neither a shackle nor a swivel between five fathoms and forty-five, it is unusual for either of them to come to the windlass in breaking ground.

The new type of shackle adopted for the Navy (Plate 87), will do away with difficulties of this kind, as the shackle, in its external size and shape, will be a duplicate of the links.

Foul Anchor. The old-fashioned anchor often comes up with one or more turns of the cable around the stock, the shank, or the flukes.

The conditions here may vary so widely that only very general rules can be laid down for dealing with them. The anchor is usually hoisted to the davit-head and cleared by dipping the chain, unshackling if necessary. Slack chain is of course paid out, and the bight is hung by slip-ropes to take the weight. If the tackle cannot be hooked in its proper place, it must be hooked to a strap. Slew-ropes on the stock are helpful in clearing the turns.

If the anchor comes up crown first, a strap is used around the arms and shank, and the crown is run up to the davit head. It may be hung there by a hawser, the tackle shifted to the balancing link, and the anchor capsized by slacking the hawser and hauling on the tackle.

Sometimes a turn around the stock can be cleared by hooking the tackle with a turn in the opposite direction to that of the chain, while the anchor is at the hawse-pipe. As the chain is surged and the tackle run up, the anchor slews and the chain falls clear.

In all cases of unshackling, a hawser should be secured to the ring of the anchor, as something may give way when least expected. Much labor in lifting and dipping the chain may be saved by the use of two pendants, the anchor hanging by one, as usual, the bight of the chain by the other. The bight being thus held, the anchor is lowered, slewed clear of the cable, and again run up. By this method, *the anchor* is dipped, instead of the chain, and the heavy work of clearing is all done by the winch instead of by hand.

Whenever possible, the anchor should be landed in its place and secured before the work of clearing begins. Where circumstances do not admit of this, it should at least be run well up to the bow and above the rail, where it can be reached conveniently. An anchor bar or small "crowbar" is very handy in opening out the parts of the chain when jammed one upon another.

Perhaps the most difficult case of fouling that can arise is one in which the chain is found hitched around the stock or the arm, with the hauling part coming out from the inside of a round turn, and with this turn jambed hard upon it. Here it is particularly important to get the anchor close in to the forecastle. The parts may be pried apart a little at a time by means of a small, flat-pointed iron bar, and the hauling part dragged through the bight by a jigger on the end of the stock, the amount gained at each fleet of the jigger being lashed before the strap is shifted for a new pull. In this way, inch by inch, enough slack is accumulated on the bight to admit of lowering it over the end of the stock or fluke, where it will fall clear.

While modern double-fluke anchors are much less likely to foul than the old type, they occasionally give much trouble in this way and a ship whose anchors house in the hawse-pipes may be greatly embarrassed by the lack of facilities for lifting the anchor to a point where it can be hung securely and where the chain can be handled conveniently.

As a rule, the best that can be done in such a case is to hang the anchor by straps and stoppers, and send men over the bow to clear the chain as best they may, assisting them from the fore-

FORECASTLE U. S. S. WYOMING.

castle by lines and tackles to take the weight of the bight. A davit which can be shipped above the hawse-pipe, plumbing the anchor as it hangs outside, is very helpful here.

If it becomes necessary to unshackle the cable, ample precautions must of course be taken to secure the anchor.

Under conditions such that the anchor may be expected to foul, it is a good rule to "sight" it frequently; and indeed this is advisable under any conditions when a ship remains at single anchor for a long time. It is especially important if, after lying for some time under circumstances which makes it probable that the anchor may be foul, bad weather is found to be approaching.

For sighting, the anchor may be lifted just far enough to be seen, or, what is usually more convenient, it may be weighed completely and another anchor let go when the cable of the first one is "up and down"; that is to say, just before the first anchor is broken out from the bottom.

ANCHORING BY THE STERN.

It is often convenient and sometimes necessary for a small vessel to anchor by the stern. For this an anchor of moderate size is usually sufficient, and it is an excellent plan to carry such an anchor at the stern ready for letting go in a hurry. If a shackle is kept at hand, and if a thimble is turned into the end of the best wire hawser, this hawser can be shackled up to the anchor and all made ready for letting go in a very short time. The ability to anchor in this way is so valuable under many circumstances, that it is surprising how rarely it is thought of or prepared for. In coming to, in a narrow or crowded anchorage with a fair tide—where perhaps difficulties are found which had not been anticipated—it might be of the greatest possible value. So, too, in going alongside a dock or into a slip, with a fair wind or tide, as it is sometimes necessary to do, a stern anchor such as has been described (not a mere kedge) might make a perfectly simple situation out of one which would otherwise be very difficult. A stern anchor of about one fourth the weight of the bowers is issued to men-of-war.

A 6000 pound anchor at the stern would not be of much value to a *Lexington* (874 feet long). And yet a ship of this length is more likely than a short one to need a stern anchor,—not only for manœuvring in restricted waters but for lying at anchor where the space for swinging is restricted; as, for example, in the

North River (New York Harbor). The latest ships designed exceed 900 feet in length. Such a ship, moored in the North River, or in almost any other harbor that could be named, would sweep practically the whole width of the navigable channel if allowed to swing. And she could be kept from swinging only if moored head and stern.

In some harbors permanent buoys are planted to which ships can tie up, head and stern, but such buoys are themselves a serious obstacle to navigation and they are rarely used except in harbors controlled by naval authorities. In commercial harbors docks and slips are provided for merchant vessels, but men-of-war must usually lie at anchor in whatever berths may be considered available by the authorities of the port.

If we imagine a division of *Lexingtons* seeking an anchorage in New York Harbor, it is easy to understand how enormously the problem would be simplified if each ship could lay out anchors from bow and stern and hold herself practically parallel with the axis of the River.

This would call for the equivalent of a bower anchor at the stern (and the bowers of the latest ships *may* weigh as much as 30,000 pounds), with all facilities for handling it, including a cable standard as to weight and length, a hawse-pipe, windlass, and chain locker.

It is clear that there are very serious objections to this, not the least of these being the proximity of the propellers. But it is not clear that something of this sort is not an inevitable development of the future. The problems of construction involved, although embarrassing, are not difficult. The problems of seamanship, such as those connected with a gale on the beam, making it necessary, perhaps, to bend a wire line to the stern cable and veer away, do not differ in principle from those connected with other emergencies which seamen are necessarily prepared to meet.

The matter is at least deserving of consideration.

In the event of stranding, such an anchor can be laid out very quickly, and while it probably would not serve to heave the ship off, it might very well hold her from driving farther on with a rising tide and at the same time prevent her from swinging around, broadside on, to the beach.

If it becomes necessary to use a *bower* anchor over the stern, the simplest way to deal with the situation is to ease the anchor

down until it hangs outside the hawse-pipe with its ring just clear, at the same time making preparations for unshackling at the 5-fathom shackle, and holding the chain—outside of this shackle—by a good slip-stopper. Pass the end of the best wire line out through the stern chock, take it forward and shackle securely to the ring of the anchor. In this as in all other cases where the anchor is to be used without its own cable, it is very important to use a "weighing-line" and buoy-rope on the crown of the anchor. (Chapter XII, Sec. 2.)

Let go when ready by knocking off the link of the slip-stopper.

If it is desired to ride by the bower cable rather than by the wire-line, pass the line forward from the stern-chock as before and stand by to shackle it to the chain when ready. Run in at slow speed to the point where the anchor is to be placed, keeping the ship under control; let go, and veer to 60 or 90 fathoms as desired, bringing-to with the shackle well inside. Pass the end of the wire line inside the hawse-pipe. Stopper the chain well, and bend on an easing-out line just forward of the shackle. Take the easing-out line to the capstan and take the strain on it. Shackle the wire line to the shackle of the chain. Unshackle the chain. Take the after end of the wire line to the after windlass. Ease out forward, heave in aft. Let the easing-out line go with the chain, standing clear of the end. Heave the line and cable in aft, and secure.

In many harbors, a swell sets in on the beam of vessels riding to the wind, causing them to roll incessantly. In such cases, a stream anchor planted off the bow, with a line from the quarter, admits of springing around, head to the swell. In the tropics, a similar plan adds much to the coolness of the ship by bringing the wind abeam.

When anchoring in a narrow river or harbor where there is little room for turning and where occasion may arise for leaving hurriedly, it is well to keep a hawser triced up along the outside from the warping chock on the quarter to the hawse, ready for clapping on the chain. If an emergency arises while the ship is heading in, the spring is bent to the cable, and the cable unshackled. The ship then swings, the line is buoyed and cast off and all is clear for standing out.

Plate No. 96.

FORECASTLE U. S. S. MISSISSIPPI.

§ IV. RIDING AT SINGLE ANCHOR.

Modern ships usually ride by one or more slip-stoppers on the chain, and with the wildcat of the windlass unlocked and the brake set up. If it becomes necessary to veer, the stoppers are cast off and the chain veered by slacking the brake. It is well to give plenty of chain in the beginning rather than to take a chance of dragging.

The advantages of a long scope of chain are universally recognized, but probably few seamen realize in just what ways such a scope contributes to the safety of the ship and the ease with which she rides.

Perhaps the most obvious gain is in the angle at which the pull of the cable comes upon the anchor. The longer the scope, the more nearly parallel to the bottom this pull will be; and the smaller, therefore, will be the tendency to break the anchor out. If the length and weight of the chain are such that any part of it rests upon the bottom, then the weight of that part is added to the weight of the anchor, and helps in this way to hold the ship. It has been found, however, that in the case of a ship riding to a moderate gale in ten fathoms of water and with 100 fathoms of chain, not a single link of the chain rests undisturbed upon the bottom. It is therefore clear that this point is not of as great importance as is commonly supposed. It is only in the two ways above described that a long scope is of value to a ship *which is pulling steadily at her cable;* but the moment she begins to sheer about, or to rise and fall in a seaway—alternately ranging up toward her anchor, then driving heavily back upon her cable—the value of a long scope makes itself felt in the elasticity of the bight, which prevents the rapidly varying tensions from being thrown upon the cable and the anchor in a succession of violent shocks. The cable never leads in a straight line from the hawse-pipe to the anchor, but dips downward in a curve, the degree of curvature depending upon the depth of water, the length and weight of the cable, and the tension to which it is subjected. With a long scope of chain, under a moderate tension, the curvature is very marked. If, now, a ship riding in this way begins to drive astern before a heavy squall, she must lift the bight of her cable as she moves; and the longer and heavier the bight, the more work will be involved in lifting it, the more slowly the ship will move astern, and the more gradually the ten-

sion on the anchor and the chain will reach its maximum. It is one of the commonplaces of mechanics that a force has far less destructive effect when exerted gradually, than when exerted suddenly; and all experience confirms this principle in its application to a vessel riding at anchor as above described.

It is a common rule to give, under ordinary circumstances, a length of cable equal to six times the depth of the water. This is perhaps enough for a ship riding steadily and without any great tension on her cable, but it should be promptly increased if for any reason she begins to jump or to sheer about; *for it is always easier to prevent an anchor from dragging than to make it hold after it has once begun to drag.*

A vessel at single anchor in a strong tide-way is likely to sheer considerably, bringing the current first on one side and then on the other, and driving across the stream until brought up by her chain, often with a violent shock. This may be prevented in a great measure by holding her with a steady sheer away from her anchor. This is accomplished by putting the rudder over as far as may be necessary, and keeping it there. The stern is driven over to one side and she is canted across the current and held there. She is thus in more "stable equilibrium" than when riding with the tide nearly or quite ahead; and while she puts a heavier tension on her cable, it is a *steady* tension, which, as already explained, is not a dangerous one.

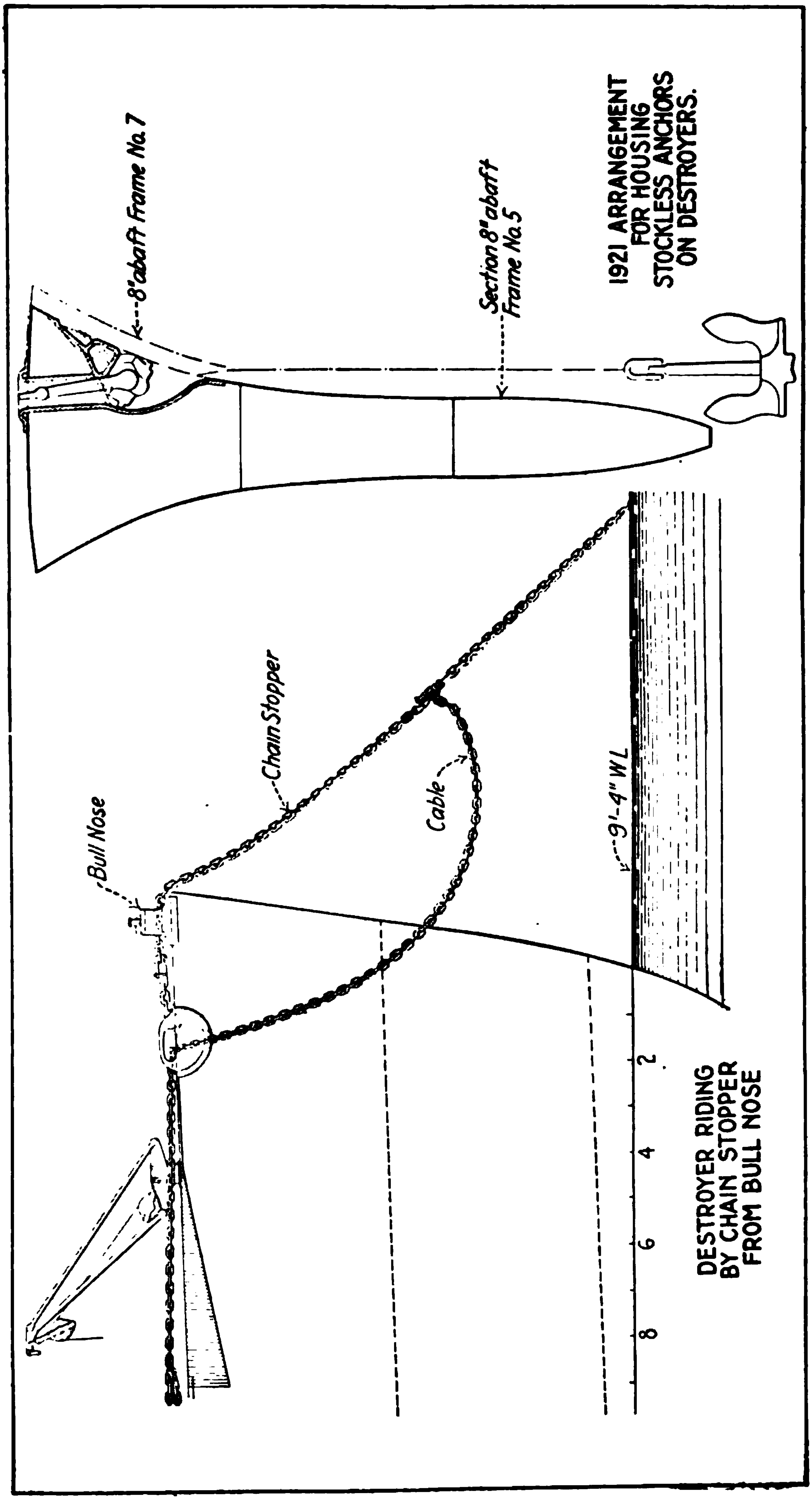
The tendency to sheer rankly from side to side under the influence of wind or tide is especially marked and especially dangerous in destroyers and other small craft. A number of plans have recently been devised for providing methods of handling the cables of these vessels in such a way that the cable shall lead directly from the stem instead of from a hawse-pipe some distance abaft the stem. (Plates 97 and 98). Reports of experiments with the new arrangement are very favorable.

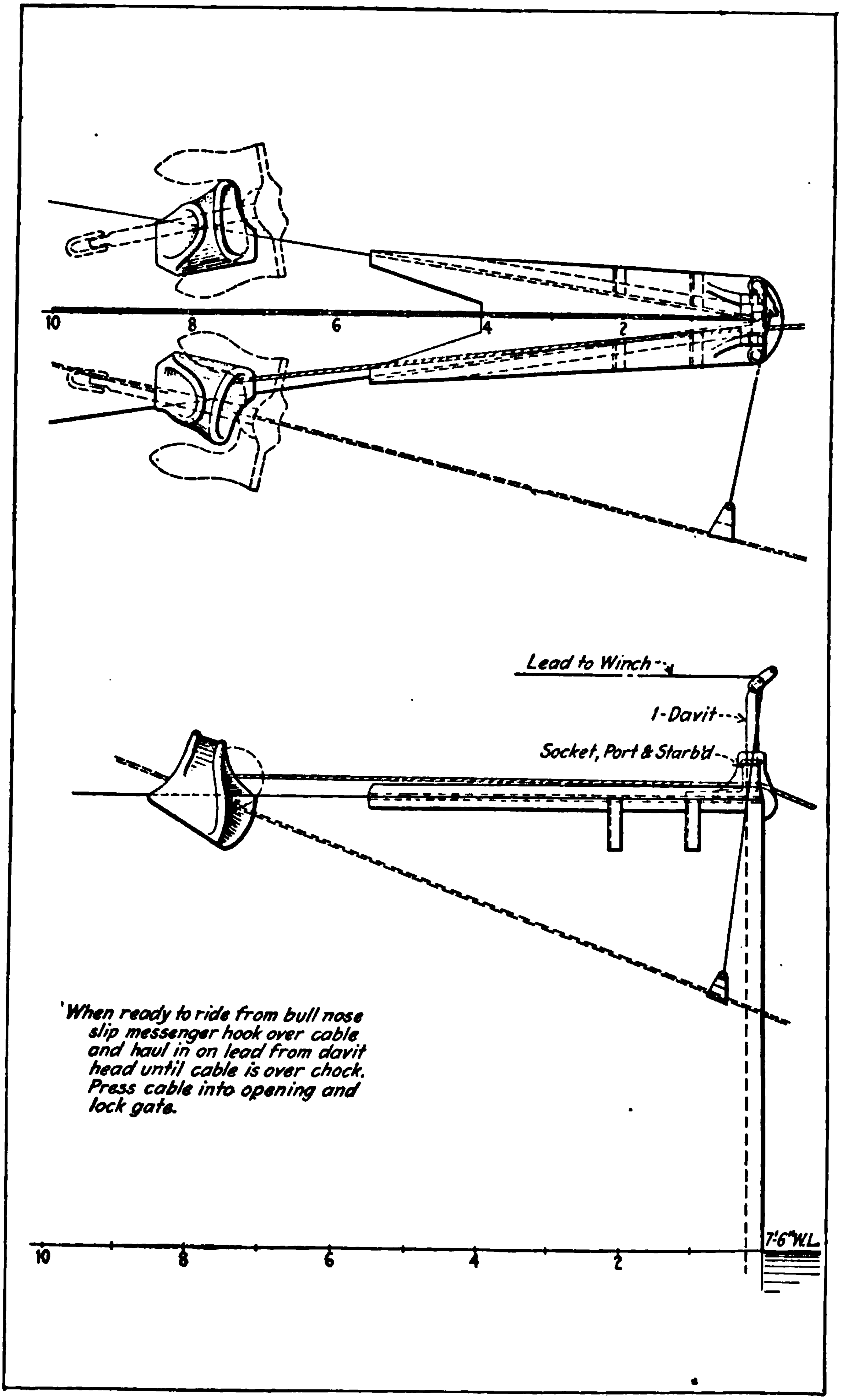
A similar arrangement applied to the latest battleships is shown in Plate 85, a mid-ship hawse-pipe being fitted in the stem.

Plate 97 also shows a new construction recently approved for the bows of destroyers, by which the anchor will be completely housed inside the hawse-pipe.

It is always advisable to keep a shackle where it can be gotten at conveniently for slipping suddenly if an emergency arises, and to be sure that the pins can be driven out without difficulty. Tools for unshackling should be kept in a convenient place and

Plate No. 97.


1921 ARRANGEMENT FOR HOUSING STOCKLESS ANCHORS ON DESTROYERS.
8" abaft Frame No. 7
Section 8" abaft Frame No. 5
Chain Stopper
Cable
Bull Nose
9'-4" WL
2
4
6
8
DESTROYER RIDING BY CHAIN STOPPER FROM BULL NOSE



EAGLE BOAT.
ARRANGEMENT FOR RIDING FROM STERN.

[illegible]

[illegible]

[illegible] ... to let go a [illegible] ... with a single anchor ... a "long scope" is not meant ... Two ... together and moored ... used separately. ... It must not be overlooked ... may result in disaster ... and this may make it wise, apart from ... to let go a second anchor in cases ... Some seamen veer to a long scope and drop a second anchor under the forefoot, leaving the brake fairly back. If the riding chain parts or the anchor drags, the slack chain on the other anchor will run out, giving warning of the danger and affording a means of bringing the ship up without the delay necessary for letting go the second anchor. If the ship swings, the anchor with the short scope of chain can be hove up before the chains foul.

A ship is never in greater danger of dragging her anchor or parting her cable than when driving down with a slack chain, broadside on, or partially so, to wind or tide. Such a situation may of necessity arise in anchoring, or may come about in sheering as above described. It not infrequently happens in squally weather, where a ship swings in one direction during a lull, just

in time to be caught by a strong squall on the beam and driven bodily off, to bring up, it may be, with the chain taut across the stem.[1]

In lying at an achorage where such situations may arise, the greatest watchfulness should be exercised, steam being kept on the steering engine, and a man at the wheel,[2] an ample scope of chain veered, and a second anchor ready for letting go at a moment's notice. The last-named precaution should in fact be always taken; that is to say, a second anchor should always be ready, even though there seems no chance of its being needed.

When the conditions are such that there is a possibility of starting the anchor, a lookout should be kept which will insure instant notice if she begins to drag. The *drift lead* is useful, though not always to be trusted. This is a heavy lead, kept on the bottom, with its line made fast to some place convenient for observation and left hanging with considerable slack. If the ship drags, the line tautens and tends ahead.

So long as a ship is fairly steady, a drift lead will usually give notice in case of dragging, but if she sheers about considerably, it cannot be relied upon. The farther forward it is used the better, as the bow moves much less than the stern in sheering.

Good *bearings* of objects on shore are more reliable than the drift lead, and a *range* is best of all; but these, also, are less trustworthy when the ship is sheering about than when she is steady; for a range will open out when the ship swings, and may seem to indicate that she is dragging. Its indications may be checked by watching the heading.

Where no range can be picked out on shore, two single marks *on opposite sides of the ship* answer well, if the observer takes his stand at some spot to which he can return from time to time, and notes a point on the ship itself in line with each of the points on shore.

Suppose, for example, that from a certain point on the bridge or deck, a shore mark to starboard is in range with a swifter of the rigging, an awning stanchion, or some other conspicuous point of the ship; while another object

[1] A cable or a hawser is greatly weakened by a bend or "nip," such as will exist at the hawse-pipe if the cable leads off at a sharp angle from the pipe.

[2] If a ship parts her cable and starts unexpectedly on a cruise, she may be in a measure controlled by the helm if actually moving through the water, and so saved, perhaps, from going ashore or fouling other vessels, until she can be brought up by another anchor.

to port is similarly in line with something on the ship along the port side. As the ship swings, one object will draw ahead and the other will draw aft. If she drags, both will draw ahead.

If the compass is conveniently placed for observation, a single bearing upon an object near the beam and at a reasonable distance, will give all that is needed, although here, also, allowance must be made for swinging.

It sometimes happens that the ship can be felt to start, by a slight jar due to the sudden slacking of the chain as the anchor lets go its hold; and if she drags for any distance, there will almost always be a tremor in the chain, perfectly perceptible to the hand, due to the variation in resistance which the anchor meets as it moves along the bottom. This is a good thing to know in cases where no other indications are available.

§ V. MOORING

A vessel is moored when she has two anchors down at a considerable distance apart and with such a scope of chain on each that she is held with her bow approximately stationary on the line between them.

A vessel so placed may head in any direction, but will swing, roughly speaking, about her own stem as a pivot; the amount by which she deviates from this depending upon the tautness with which she is moored.

The advantages of mooring are that a vessel takes up comparatively little space in swinging and that she cannot foul her anchors by dragging the bight of the chain over them. The disadvantages are that she must often ride to a span, and must either be hampered by a mooring swivel or have constant difficulty and annoyance from a foul hawse. So long as she rides to a wind or current setting along the line on which her anchors are laid out, she is practically at single anchor, though she may of course drop down beyond the leeward anchor and hold on with both cables taut ahead. But if a gale comes up from any direction athwart the line between her anchors, she rides to a span, and the tension on the cables will be altogether out of proportion to that utilized in holding the ship. In Fig. 1, Plate **99**, suppose A riding to a gale from the east, her anchors being laid out on a north and south line and the cables making an angle of 10° with this line. If the force acting on the

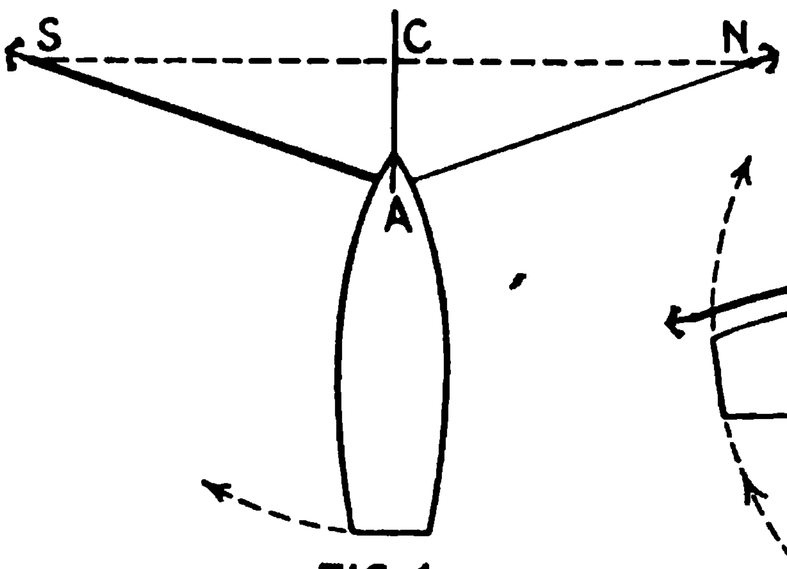


FIG. 1.
OPEN HAWSE

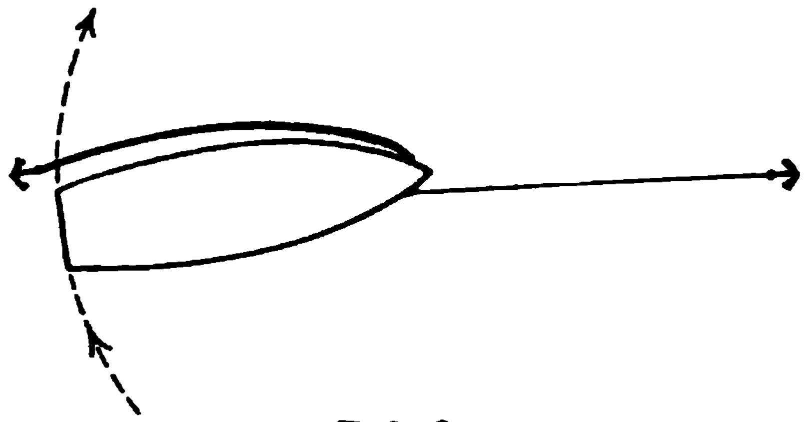


FIG. 2.
OPEN HAWSE

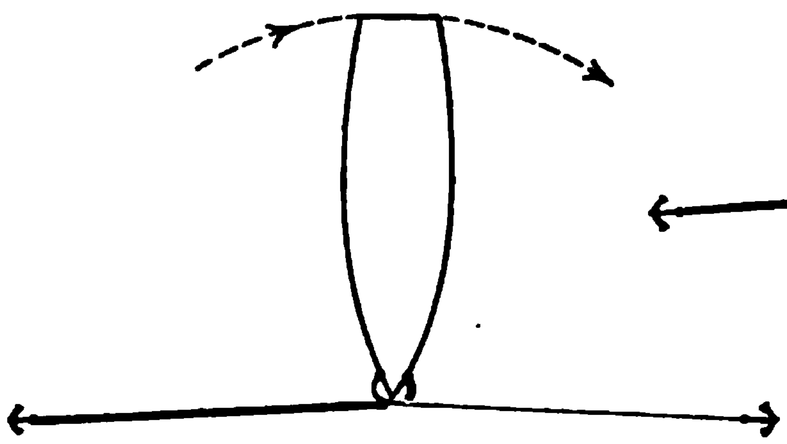


FIG. 3.
A CROSS IN THE HAWSE

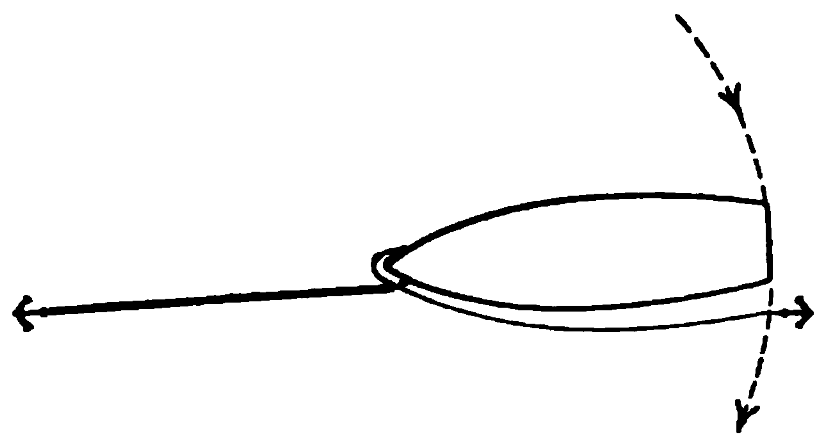


FIG. 4.
A CROSS IN THE HAWSE

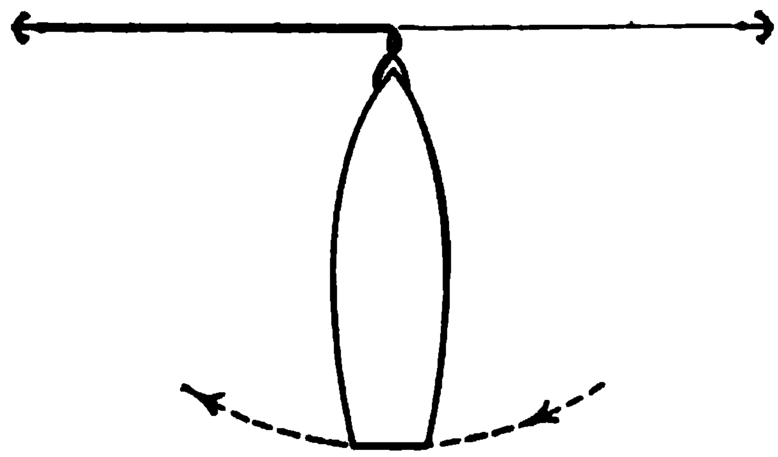


FIG. 5.
AN ELBOW

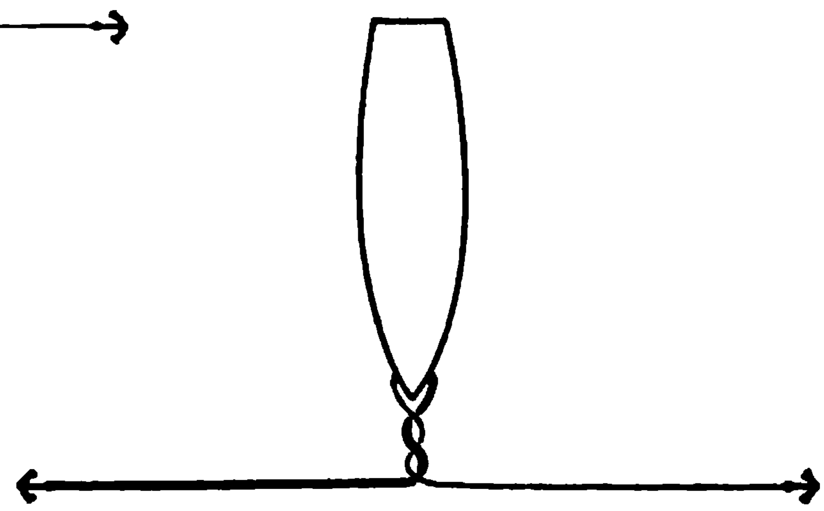


FIG. 6.
A ROUND TURN

SHIPS MOORED.

ship along A C is 20 tons, the tension on each cable will be 57½ tons.

Thus, under conditions such that a single anchor and cable ahead would have to bear a tension of only 20 tons, two cables in a span are subject to a total tension of 115 tons. If the angle N A S is more obtuse, the tension is increased. If the ship veers and drops to leeward, bringing the cables more nearly ahead, the demand upon them becomes less; and when the angle N S A is 30°, the two cables together have exactly the holding power that one would have if laid out singly ahead. As the ship continues to drop down, the cables act more and more efficiently, and if a long enough scope is given, their holding power becomes nearly double that of either one alone.

It will be clear from this that in riding out a gale with open hawse it is even more important than with a single anchor, to veer as long a scope as may be possible. If such a situation is anticipated at the time of mooring, the anchors should be laid out closer together than they otherwise would be; indeed, there is always an advantage in mooring with rather a short scope on each chain (provided such a length is used that she cannot swing over her anchors); for if a gale comes up along the line of the anchors it is easy to veer the riding cable and drop down to leeward, bringing both anchors ahead, where they will act better the closer they are together; and in riding with open hawse, the same point gives the advantages which has been illustrated above.

If a mooring swivel is to be used, these remarks as to the advantage of a short scope do not apply, since it is impracticable to veer away on both cables as above recommended.

There are many situations in crowded harbors where mooring is a necessity, especially if a number of ships are together in squadron. When this is not actually necessary, it is safer and more convenient and therefore more seamanlike, to use one anchor, with a good scope of chain which can be practically indefinitely increased if necessity arises, and with the second anchor ready to be let go on the line where it will be most effective.

TO MOOR.

In mooring in a tide-way, where it is desired to lay out the anchors along the line of the tidal current, as is usually done, the simplest way of maneuvring is to head up against the current,

stopping at the point where the "weather" anchor is to be planted and letting go as the ship begins to gather sternboard, backing the engines if the tide is not strong enough to insure laying out the chain properly. It is better not to use the engines unless necessary, because to do so is almost certain to cut the ship across the current and off the line on which the anchor should be laid out.

The weather chain is veered away as the ship drops down, care being taken to lay it out fairly taut, until the point is reached where the leeward anchor is to be placed. If we are to moor with 45 fathoms on each chain, we must veer to a little less than 90 fathoms before letting go the second anchor, keeping the 90-fathom shackle inside the hawse by an amount which will depend very largely upon the method which is to be used for putting on the swivel. The farther inside the hawse we leave the shackle, the slacker will be the moor, and as the putting on of the swivel in itself slacks the cables materially, care should be taken not to keep the shackle farther inside than is absolutely necessary. No rule can be given here, but experience has indicated that if the first chain is laid out properly, and if the 90-fathom shackle is held about 2 fathoms inside the hawse (counting from the outboard face of the pipe), when the second anchor is let go, the resulting moor will be about right, with most types of ships and in ordinary depths of water.

A FLYING MOOR.

In making a flying moor, the first anchor is let go with the ship going ahead at considerable speed, and the first chain laid out as she ranges ahead. This calls for good judgment with regard to the initial speed, and with regard also to the use of the chain and the engines for checking the speed.

It has been already stated in connection with "Anchoring" that almost any ship, except one with turbine engines, running at a speed of from 4 to 5 knots, with steam available for 12 knots, and backing with full power as the anchor is let go, can be brought up at 45 fathoms without undue strain. Since for mooring we wish to run out double this length of chain (assuming that we want 45 fathoms on each anchor), we may back with half power in the beginning and be governed by conditions as to using more power or less, as the chain runs out. It will probably be found

under average conditions that by continuing to back with half power and gradually snubbing the chain toward the end of its scope (never in the beginning) she can be brought up with about 90 fathoms.

It is very important not to begin to snub her with the chain until at least 45 to 60 fathoms has been laid out, as to do so is almost certain to start the anchor or part the chain, or at least to strain it injuriously. After laying out a good scope—45 fathoms or more—the danger of this is greatly reduced and a little snubbing helps to lay the chain out taut.

As a very rough rule, then, to be modified by actual experience for each ship, we may say, let go the first anchor at a speed of from 4 to 5 knots and at once back the engines at half speed, letting the chain run out freely. After about 60 fathoms has gone out, snub her from time to time with the chain, but without putting a dangerous strain on it, and regulate the engines (stopping, backing faster or slower, or if need be going slow ahead) so as to be sure of *bringing her up* in the end (the 90-fathom shackle inside) *with a moderately taut chain*. Then let go the second anchor, heave in on the first chain, veer away on the second, and drop *down* to a point midway between the two anchors, when both shackles should be somewhat inside the hawse, giving drift enough for working the chain as described below for clearing hawse or for putting on the swivel.

For a ship with turbine engines, the initial speed should be lower than with reciprocating engines or electric drive.

Note the remarks upon the method of governing speed in approaching an anchorage in the section of this chapter on "Anchoring."

CLEAR AND FOUL HAWSE.

A vessel moored has a "clear hawse" when her cables lead off on their respective sides, clear of each other. She has a "foul hawse" when they are crossed or otherwise foul of each other.

In Fig. 1, Plate 99, A rides with an "open hawse," heading west, her starboard anchor being to the north and port anchor to the south. She may swing through eight points to either side without crossing her cables (Fig. 2); and so long as she swings backward and forward, *her stern going each time to the eastward*, the hawse will remain clear. The moment her stern swings to the westward of the north and south line, however, the chains

begin to cross (Fig. 3). Here she has swung through half a circle from an open hawse, and has now a "cross" in the hawse. If before swinging to the westward she was riding to the starboard anchor, the starboard chain will now be on top; and to swing clear, her stern should go back to starboard. It is a rule easily remembered, that to clear the hawse by swinging, the stern must always go toward the side of the cable that is on top.

If, having swung in such a way as to put a cross in the hawse, she continues swinging in the same direction, she puts in, successively, an "elbow" (Fig. 5), a "round turn" (Fig. 6), a "round turn and an elbow," and so on.

It is evident that a foul hawse will be cleared if the ship can be made to swing back in the direction opposite to that in which she has swung in fouling; and with a little watchfulness this may often be done, by giving her a cant with the rudder on the last of a tide. The hawse may often be kept clear in this way when it would otherwise foul; and the situations are frequent when a cross or an elbow can be swung out. In the case of anything more than this, it is better to proceed at once to "clear hawse," as follows:

TO CLEAR HAWSE.

This should be done if possible at slack water, preferably just after the ship has finished swinging and before the new tide begins to run strongly. The lee chain is always the one to be unshackled, never the weather one. The clear-hawse gear (Plates **100, 101, 102**) consists of:

1. The *clear-hawse pendant,* of open-link chain, 6 fathoms in length and of metal one-half the diameter of the chain with which it is to be used. The outer end of the chain is fitted with a *slip,* or pelican hook. The inner end is fitted with a shackle having a round bolt and a solid thimble into which is spliced a tail of wire-rope about 30 fathoms long.

2. The *dip-rope,* of open-link chain or, still better, of 3-inch circumference wire, about 6 fathoms in length, the outer end of which is fitted with an eye carrying a shackle large enough to engage a link of the cable. To the other end is fitted a tail of 7-inch manila about 30 fathoms in length. The outer end, of chain or wire, takes the chafe in the hawse-pipe, and the manila tail goes to the wild-cat, where it is found to work more smoothly than if made of wire as was formerly the practice.

3. A *hawser* to be bent to the chain above or below the slip-

Plate No. 100.

CLEAR-HAWSE PENDANT
2¾-inch, 15 fms.

CLEAR HAWSE GEAR.

hook of the clear-hawse pendant, as a preventer, in the event of parting the pendant.

4. A *line* on the chain from the inside, for easing out after unshackling. This is not always used, but is convenient and may be necessary with a heavy chain.

5. *Deck tackles, hook ropes, chain hooks, straps, rope* for lashing, *tools* for unshackling and shackling, etc.

If the turns in the cables are below water, they must be brought above by heaving in the riding cable. If they are inclined to slip down—as may be the case if the chains are slack—they must be lashed; and many officers prefer to lash them in all cases. There is no question that this reduces the chance of accident, both to the cables, and, what is more important, to the men working them.

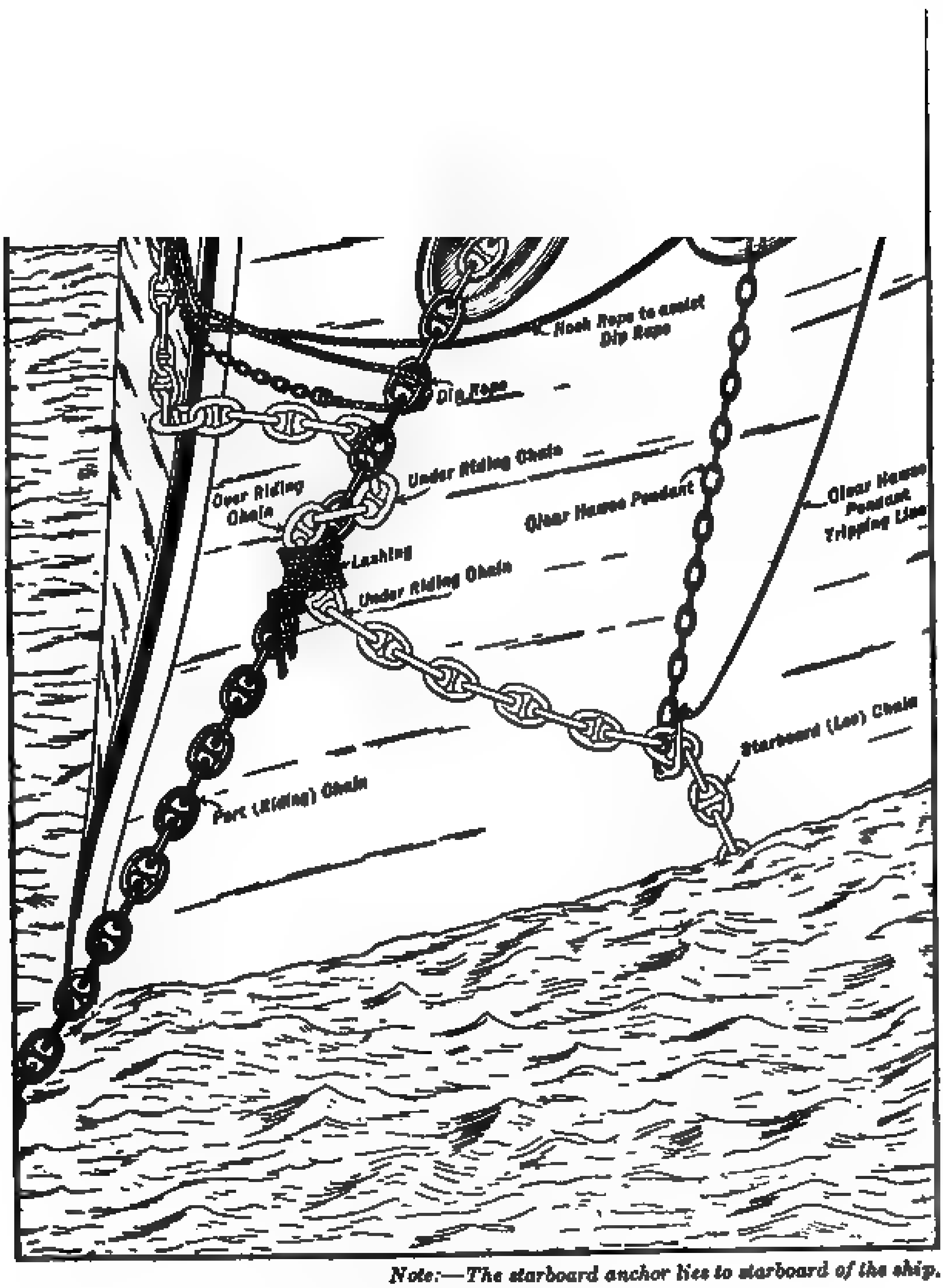
A ship with a ram-bow, having a foul hawse, will sometimes forge ahead, bringing the turns below the ram so that the cables lead up and down and seem to be clear; and in any type of ship, if the moor is rather slack, there are chances that the hawse will look clear when it is in fact very badly foul. If proper entry has been made in the log of the swinging of the ship, this should not lead to misunderstanding, but it may cause considerable difficulty. If steam is available, a few turns of the screw astern will bring the turns up where they can be gotten at. In other cases, it will usually suffice to heave in on the riding cable and veer on the lee one. Much depends upon the shape of the ram and the position of the hawse-pipes, but there is always some way of handling the chains to meet this and other difficulties which arise in working ground-tackle.

The turns being above water, the clear-hawse pendant is passed out the sheet hawse-pipe or through a warping chock, and secured to the lee cable below the turns, after which it is taken to the capstan or a winch, hove taut and secured.

In a ship with a ram-bow, the turns usually come up on one side of the ram;—the side of the riding cable (Plate 102). In this case, the clear-hawse pendant, although still used on the lee cable, is passed out on the side of the *riding* cable.

The preventer hawser is also passed out, bent to the cable, hauled taut and secured.[1] If the turns are to be lashed, this is done now.

[1] This supposes that the preventer hawser is to *hold* the chain in case the pendant fails. If it is intended only for *weighing* the chain, it is left slack but the end is made fast. The latter is the better plan.



Note:—The starboard anchor lies to starboard of the ship.

CLEARING HAWSE.

BOTH CHAINS ON WEATHER SIDE OF RAM.

The dip-rope is passed out of the hawse-pipe alongside the lee cable, taken around the riding cable in a direction opposite that of the turns to be taken out, and brought back inside, where it is secured to the cable forward of the shackle; preferably to the end link.

The dip-rope is often made fast to the second or third link forward of the shackle, to leave slack on the end for convenience in shackling and unshackling; but this makes trouble when it comes to hauling the end in through the hawse-pipe; and the better way is to bend it to the end. Then, after the turns have been cleared and the end hauled in again ready for shackling, the chain is secured with a stopper, leaving plenty of slack end for working, and the dip-rope is cast off altogether.

The lee chain is secured by a stopper and the end of the "easing-out" rope made fast a few links forward of the shackle and stopped to the end link. The cable is then slacked up and unshackled, the controller released, and the chain hauled out by the dip-rope, the end of which is taken to a winch.

The lead of the dip-rope is unfavorable for hauling out, and with a heavy chain it may be necessary to lead a line out on the side of the riding cable, and take it in through the lee hawse-pipe to assist in hauling out the end of the cable (Plate 102). Chain-hooks, hook-ropes, etc., are used inside for lighting the chain forward.

The dip-rope, assisted as before described if necessary, takes out the turns and brings the end inside the hawse-pipe, where it is secured by a stopper and shackled. The chain (lee) is then hove moderately taut, the controller released, the preventer hawser cast off, and the clear-hawse pendant tripped by means of the lanyard on the link.

On large ships the chains usually cross below the water-line, even although they are hove taut; and to put on the heavy clear hawse-pendant and secure a preventer hawser over the bow is very difficult. This difficulty is overcome by securing the lee chain *on deck,* by stoppers, rousing out sufficient chain to reach around the riding chain as many times as there are turns in the foul hawse and back on deck, and unshackling. The dip-rope is rove around the riding chain in the proper direction for clearing the hawse, hooked to the end link of the outboard part of the lee chain and hauled taut. An easing-off line is secured to the bight to be eased out, and a heavy hook-rope and a line for hanging the bight are put over the bow. When the lee chain is eased out, it is lighted around the riding chain by means of the hook-rope and hanging line, while at the same time the

dip-rope takes in the slack. When enough slack is on deck to shackle up, the lee chain is again connected, the clearing gear gotten out of the way, and the lee chain hove in by the windlass until it is clear of the riding chain.

In small ships the hawse is often cleared from a boat under the bow, the shackle being veered out into the boat and there unshackled, dipped, and shackled again. It is well in this case to lash the turns and to take the weight of the chain by slip-ropes from the bowsprit or forecastle.

Some ships have a light davit which can be stepped at the stem when needed for working chains. This is a great convenience and in many ships almost a necessity.

A cross in the hawse cannot be cleared, as the chains lead off on the wrong sides, the starboard anchor being on the port hand and the port anchor on the starboard hand. The chains may be unshackled and shifted, the former starboard chain becoming the port one and the port becoming the starboard, provided this does not interfere with stowing the anchors.

As modern ships carry three anchors, all of which are in effect bowers, two of these must necessarily be carried on the same bow, except that in the latest ships, one is carried at the stem (Plate 85). The difficulties of clearing hawse are much reduced by mooring with the two anchors on the same bow, or one on the bow and one on the stem.

If it becomes necessary to weigh when there is a cross, the anchor belonging to the cable *underneath* must be picked up first; as the upper one, if picked up, would foul the other chain.

It is clear from what has been said about the hawse, that it is not a matter of indifference in what way the anchors are laid out. In Fig. 2, Plate 99, for example, they are properly placed provided the probability is that the wind, in the event of bad weather, will haul to the westward, thus keeping the hawse open. If the wind is more likely to haul the other way, the starboard anchor should be to the southward.

THE MOORING SWIVEL.

A vessel moored may avoid the necessity for clearing hawse by using a mooring swivel (Plate 101). This is much like an ordinary swivel, but larger and heavier and with two links and shackles attached to each of its parts. It is shackled upon the cables just forward of the stem in such a way that the parts

of the cables leading from the hawse-pipes are connected to the inner shackles, and the parts leading off to the anchors, to the outer shackles. As the ship swings, the swivel turns and keeps the cable clear. It should be put on with the cup up.

There are some disadvantages connected with the use of the swivel. It is very inconvenient in veering, and still more so in weighing, as it must be taken off before either anchor can be picked up. In spite of these disadvantages, it is almost invariably used by men-of-war.

In view of the difficulty in veering where the swivel is used, a vessel proposing to use it should moor with a good scope on each chain in the beginning. The conditions here are quite different from those where a ship is moored without a swivel and free to veer at any moment. Under the last-named conditions, as has been explained, there is a certain advantage in having the anchors not too far apart, but this reasoning does not apply if the swivel is to be used.

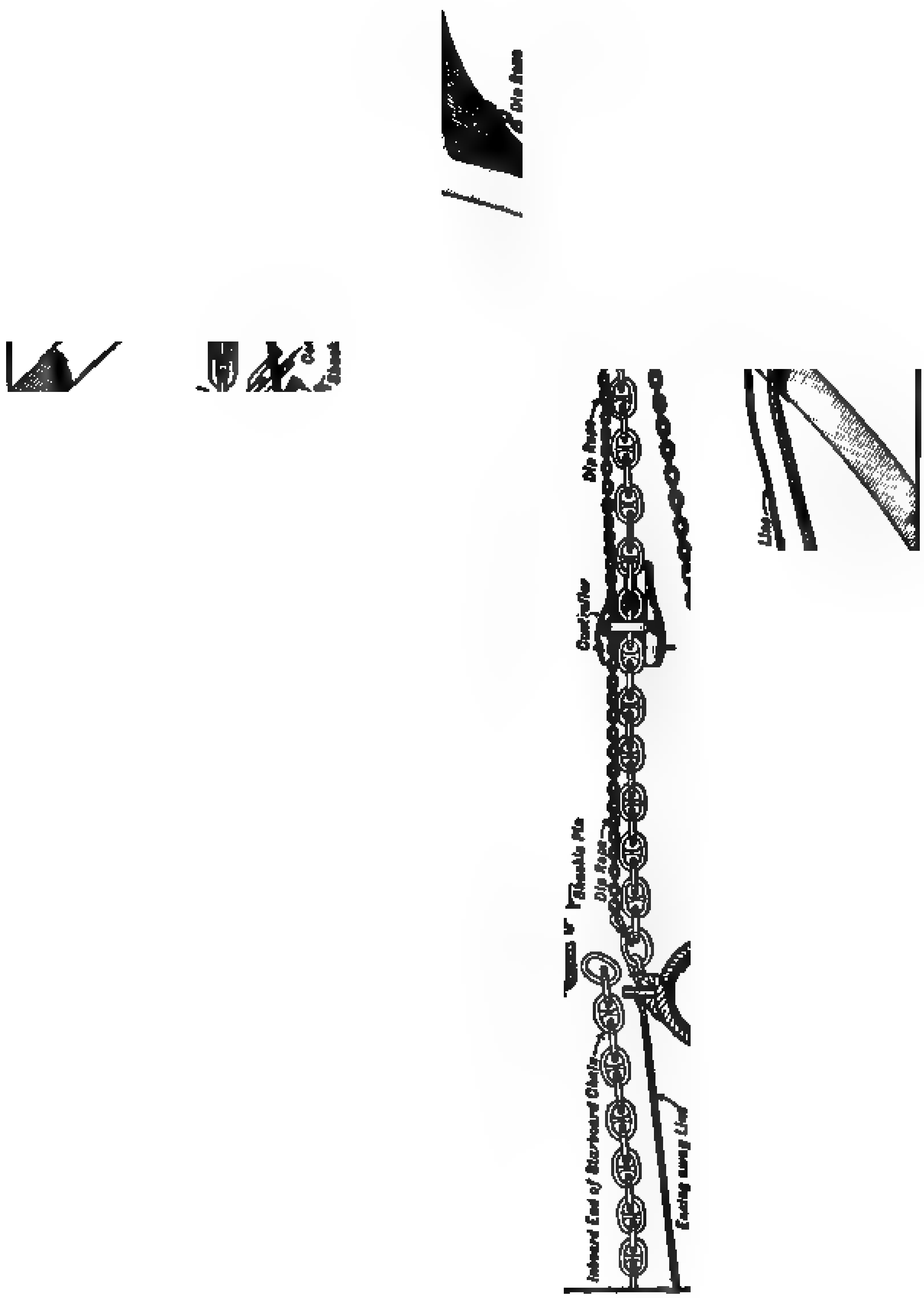
As both clearing hawse and putting on the mooring swivel involve unshackling, the scope on each cable in mooring must be made such as will bring a shackle near the hawse. Where the cables are made up of 15 fathom shots, we may use 30, 45, 60 or 75 fathoms on each. In the United States Navy, the latest cables issued to ships have no shackle between five fathoms and forty-five, so that nothing less than forty-five fathoms can be used on either cable (in mooring).

It is usual in laying out the cables to bring the shackles a little inside, but not so far as in cases where the swivel is not to be used. This is because the insertion of the swivel slacks the cables considerably, and with a slack moor there is danger that the swivel will not turn. The exact position for the shackles will depend upon the depth of water and the construction of the ship.

It is a common and convenient practice in using the swivel to connect only one cable from the hawse, the end of the other being kept inboard. This does not involve any loss of holding power, for the reason that, so long as the ship rides to one cable only, the single part leading inboard is as strong as that from the anchor; and when she rides with an open hawse, the parts beyond the swivel form a span, which, as has been shown, has actually less holding power than a single part acting along the line on which the ship is pulling.

Some ships shackle both chains from inboard to the swivel,

Plate No. 103.



CONNECTING SWIVEL UP INSIDE HAWSE.

and to prevent them from sawing across the stem leave one of them slack and dip the bight of it down under the forefoot. They thus ride to a single part, but have the other to rely upon in case of accident and can heave the swivel up to either hawse-pipe for taking it off.

PUTTING THE SWIVEL ON.

It was formerly the rule to put the swivel on the lee chain first, then to wait for the ship to swing before putting it on the other one. This is still the rule in cases where the swivel is put on *outside the hawse.* But many modern ships have hawse-pipes large enough to let the swivel and several parts of chain pass freely; and in such ships it is put on inside, *and on the riding cable first,* the lee cable being afterward secured by the clear-hawse pendant as in clearing hawse, unshackled, and the end coming from the anchor hauled around the stem and inside the riding hawse-pipe, where it is shackled in its place on the swivel.

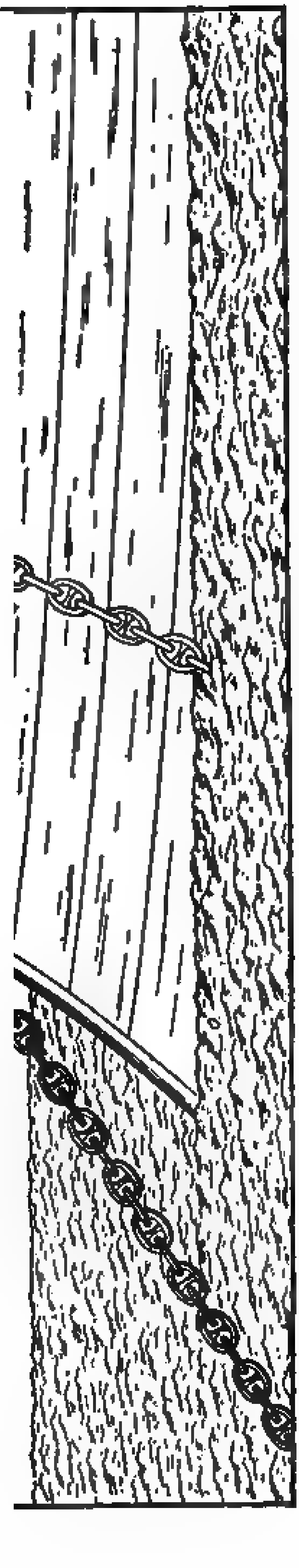
First Method. The details of this method are shown in Plate 103.

The first thing to be done is to heave in on the *riding cable* until the shackle is inside and at a convenient point for working, when the chain is secured by one or more stoppers, all of course forward of the shackle. The riding cable is then slacked abaft the stoppers and unshackled, and the swivel shackled in place. In the meantime, the clear-hawse pendant has been put on the lee cable and hove taut, and a preventer hawser made fast, as in clearing hawse. The dip-rope is passed out through the riding hawse pipe, brought in the lee hawse pipe, and made fast to the lee cable just forward of the shackle.

The lee chain is next unshackled inside, and the end of it leading from the anchor is hauled out by the dip-rope, across the stem and in through the riding hawse-pipe, where it is shackled to the *forward* end of the mooring swivel. The riding chain is then veered away until the swivel is outside.

If, now, it is proposed to connect the other part of the lee cable (from inboard), this part is hauled out by the dip-rope and shackled in its proper place on the swivel.

Second Method. If the hawse-pipe is large enough to take the swivel, but not large enough to take the two cables alongside each other, the swivel is put on the riding cable as just described and



PUTTING ON OR TAKING OFF SWIVEL OUTSIDE.

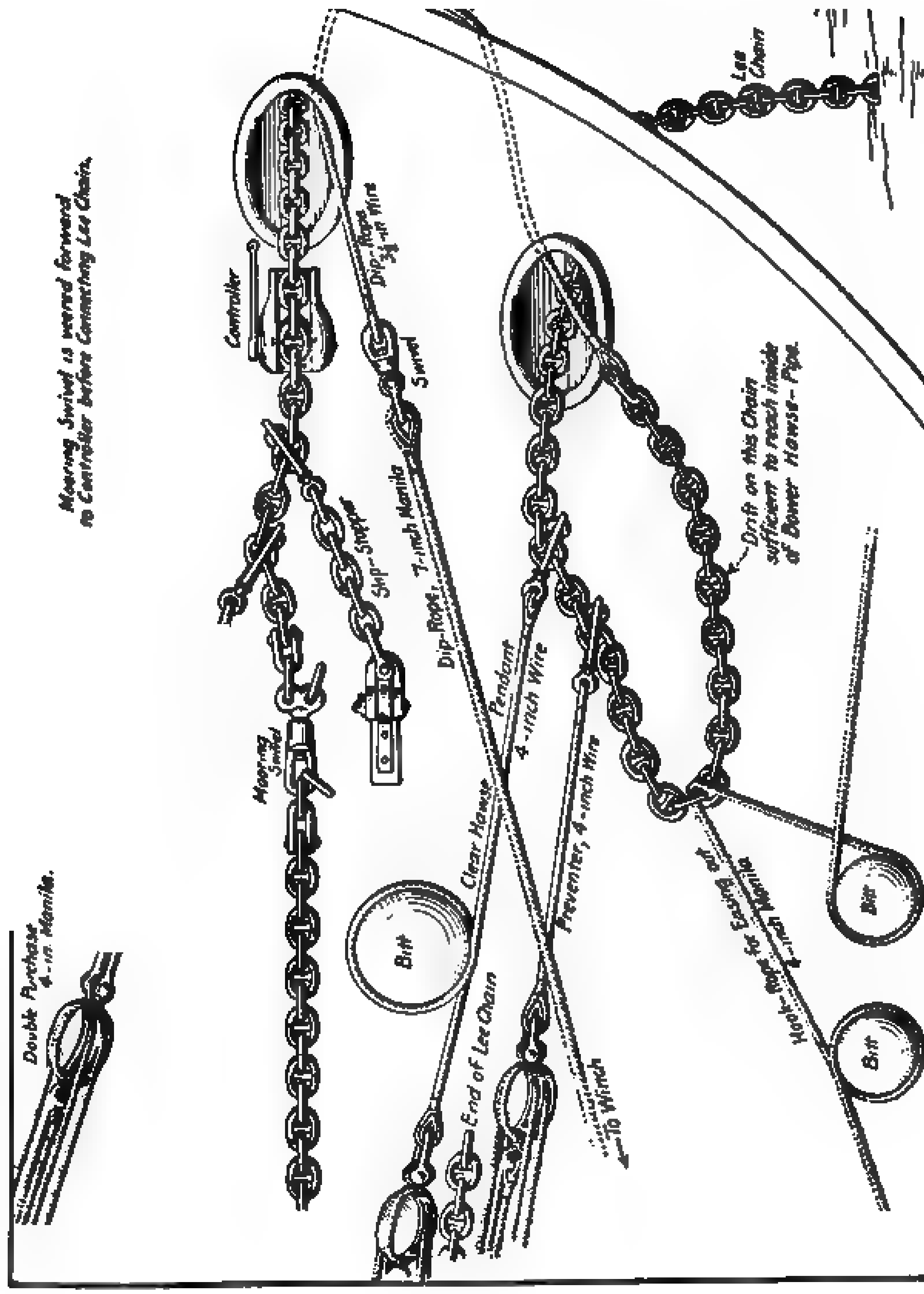
then veered outside, before connecting up the anchor end of the lee cable; the clear-hawse pendant, dip-rope, etc., being used as before, except that the dip-rope in this case would be rove a little differently; perhaps through a link of the riding cable just below the swivel, or even through the swivel itself; the idea being to get the end of the chain to the point where it is wanted, by whatever means is most convenient (Plate 104). In this case also it is necessary to bend the dip-rope to the lee cable several links forward of the end, to give the slack required for shackling. The men handling the chain work either in a boat under the bow or on a stage slung over from the forecastle, such lifting as is required being done by slip-ropes, and all shackles, mauls, etc., being slung by lines to avoid danger of their being lost. This method gives a tauter moor than either of the methods, already described, in which both chains are shackled to the swivel inside the hawse.

Third Method.[1] Plate 105. This resembles the First Method above, but with several important points of difference, the most important being the following: all gear is kept inside and no one is sent over the bow at any stage of the operation; wire-rope pendants are substituted for chain as being more reliable, and two-fold purchases are used with the pendants, giving a gain not only in power but in smoothness of working; work proceeds on both chains simultaneously, giving a marked gain in time; the chains are under perfect control at all times, all violent "surging" being avoided.

The gear consists of: a *clear-hawse pendant,* two *preventers,* a *dip-rope,* an *easing-away line,* and *deck-stoppers* as required.

The clear-hawse pendant and both preventers are of 3½-inch wire, with a pelican-hook at one end for engaging the chain and an eye in the other end, to which is shackled the block of a heavy two-fold purchase. The dip-rope is in two parts connected by a swivel to prevent the accumulation of turns as the chain is hauled around, the outer part, of 3-inch flexible wire, about seven fathoms in length, shackling to the lee chain; the inner part, of 7-inch manila, leading to the winch. The size of gear required will of course vary for different ships. The dimensions given are suitable for ground-tackle such as is used by the "Rhode Island" class of battleships.

[1] This method was worked out by chief boatswain J. P. O'Neill, U. S. Navy, and used with excellent results on the U. S. S. "Rhode Island."



PUTTING ON SWIVEL—THIRD METHOD.

The dip-rope is rove off as the anchorage is approached, out through the forward hawse-pipe and in through the after one (assuming that the after anchor is to be the first let go). The dip-rope is made fast at some convenient place on deck and hauled taut to keep it clear as the chains run out when the anchors are let go.

All gear is broken out and each part is placed as nearly as practicable where it is to be used; the blocks of the clear-hawse pendant and the two preventers being hooked to their respective pad-eyes or straps, and the falls overhauled to the proper length, but all placed carefully where they will be clear of the cables. If a bitt is conveniently placed for the purpose, it is well to take a turn around it with the clear-hawse pendant, as shown.

One great advantage of this method is that both cables may be handled at practically the same time; and all preparations, including the assignment of men to the various duties, should be planned with this in mind.

The lee anchor having been let go, the riding chain is hove in until the shackle is at the proper point, which on the "Rhode Island" is found to be just forward of the bitt.

Both cables are now secured as shown in the plate; the riding cable by the deck-stopper and the preventer, and the lee one by the clear-hawse pendant and preventer, the purchases of the clear-hawse pendant and both preventers being hauled taut and belayed.

In securing the riding chain, about three links are left between the deck-stopper and the preventer. The point for the clear-hawse pendant and preventer on the lee chain is determined by the consideration that this point must be far enough outside the shackle to give a length of chain sufficient to lead out through its own hawse-pipe and in through the other pipe to the point where it is to be shackled to the swivel, which will be a short distance inside the other hawse-pipe. Both chains are now broken at the shackles and the riding chain is connected up to the swivel. At the same time, the lee chain is hauled around by the dip-rope, the bight of the chain being eased out by the bight of the hook-rope, as shown. The chain is thus kept under control and the heavy surge on the clear-hawse pendant which would result from letting the bight go out by the run, is avoided.

As soon as the riding chain is shackled up to the swivel, the strain of the chain is taken with the anchor-engine. The slip-

hooks of the deck-stopper and the preventer are knocked clear, and the chain is eased out until the swivel is just inside the hawse. This reduces the length required on the lee chain to reach the swivel, and so gives a tauter moor. The lee chain having been hauled inside is shackled to the swivel.

The slip-hooks of the clear-hawse pendant and the preventer are now knocked clear of the lee chain, allowing the bight to run out, after which the swivel is veered outside.

Fourth Method. Plate **106.** This method was developed by Chief Boatswain M. H. Eldridge, and used by him on the U. S. S. Wyoming. It goes farther than either of the preceding methods in reducing the amount of gear that must be used, and, what is more important, provides for doing most of the work required in advance of the time of actual mooring and while the ship is approaching the point where the first anchor is to be dropped.

The starboard anchor is lowered and hung by one slip-stopper, ready for letting go. The port anchor is lowered and hung by two slip-stoppers and the port chain unshackled at five fathoms, after which the after-length of the chain is dipped outside the port riding-bitt and hauled across the forecastle to a point near the starboard hawse-pipe. The dip-rope is rove out through the port hawse-pipe, across the stem, and in through the starboard hawse-pipe, where it is bent to the free end of the port chain. The port chain is next hauled by means of the dip-rope out through the starboard hawse-pipe, across the stem and in through the port hawse-pipe, where it is shackled up to the five-fathom length which has remained attached to the anchor. The port anchor is then eased down until the after-stoppers take the strain. The dip-rope is unbent and gotten out of the way, and all is ready to moor without the further use of a single piece of gear.

When in position for dropping the first anchor, if a flying moor, the starboard anchor is let go and the chain laid out. While the starboard chain is running out, a sufficient length of the port chain is roused out through the starboard hawse-pipe to insure the port anchor reaching the bottom without a sudden jerk of the chain. The forward stopper is now taken off the port chain, leaving the anchor hanging by one slip-stopper ready for letting go.

As the ninety-fathom shackle comes to the proper point (dependent upon the depth of water and the tautness of moor de-

Plate No. 106.

MOORING AND PUTTING ON THE SWIVEL—FOURTH METHOD.

sired) the port anchor is dropped, and the chains are adjusted to forty-five fathoms on deck. Two stoppers are now put on each chain, the cables are unshackled, and the two forward lengths shackled to the forward links of the mooring swivel. The after-length of the starboard chain is shackled to one of the after-links and the mooring swivel is veered outside.

If, instead of making a flying moor, the ship is to back away from the first anchor dropped, the port anchor must be let go first, the rule being that the anchor let go "on the bight" should always be the one to tend ahead.

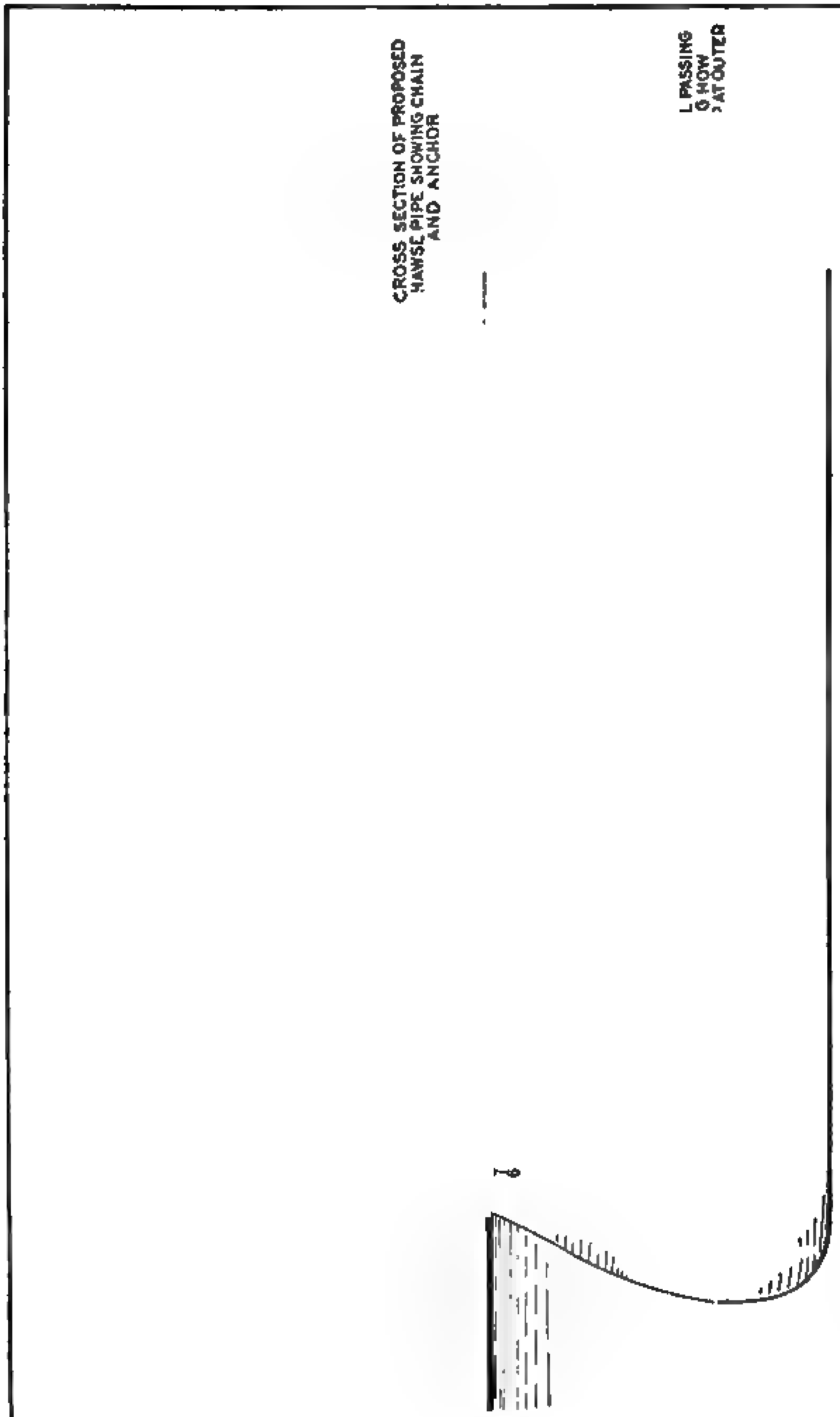
The convenience of the method above described is even greater in cases where the two anchors to be used are on the same side of the bow, than in the case above described where they are on opposite sides, for the reason that in this case there need not be any large bight of chain hanging over the bow while the ship is approaching her anchorage and while she runs out the first chain. Plate **107.**

A trifling inconvenience connected with the Eldridge method is the fact that the port chain lies in the starboard hawse-pipe, alongside the starboard chain, during the time that the starboard chain is running out. This is not at all a serious matter, but a hawse-pipe has been designed and is under consideration for installation in future ships, which includes a lip on the inside of the hawse-pipe by which the chains can be held clear of each other. The details of this design are shown on Plate **107.**

If the swivel cannot be put on either cable inside, it must be put on the lee cable first, the shackle being veered outside, the cable secured by the clear hawse-pendant and a hawser, and the swivel lowered over the bow and put on by men working in a boat or on a stage. When the ship has swung, bringing the other cable to leeward, this is handled exactly as has been described for connecting the lee cable in the case where the swivel was put on the riding cable inside and veered outside.

Taking off the Swivel Inside.—This is practically the reverse of putting on. In most cases the operation is simplified by first unshackling the inner part of the lee cable from the swivel, *outside*, and heaving the end inside its own hawse-pipe. The riding cable is then hove in, bringing the swivel and the outer parts of both chains inside the hawse, where both chains are well stoppered. The clear-hawse pendant is bent to the lee cable, outside,

Plate No. 107.



MOORING AND PUTTING ON SWIVEL WHEN BOTH ANCHORS ARE ON THE SAME BOW.

and hauled taut, and a preventer hawser used as in putting the swivel on. (Plate 103.)

The two parts of the riding cable are unshackled from the swivel and shackled together. The dip-rope is rove out through the lee hawse-pipe, in through the riding hawse-pipe and bent to the end of the lee cable just forward of the swivel, ready to haul the end around. The easing-out rope is bent to the same end, hauled taut and belayed. The lee cable is then unshackled from the swivel and the end hauled around and in through its own hawse-pipe (being eased away to avoid surging), and shackled up to its own part.

Taking off the Swivel Outside (Plate 104).—Secure the lee chain as for clearing hawse; that is to say, put the clear-hawse pendant and preventer hawser on that part of the lee chain leading from the anchor and heave in on the clear-hawse pendant until there is slack enough between it and the swivel for unshackling. If the inboard end of the lee chain is shackled to the swivel, stick out slack enough for unshackling it also. If this end is not attached to the swivel, haul it out by the dip-rope leading from the weather sheet pipe. Hang both parts of the lee chain by good lines from the forecastle. Unshackle both ends from the swivel and shackle them together. Heave the lee chain taut, take off the hawser and slip the clear-hawse pendant. Heave in on the riding chain until the swivel is abaft the controller. Secure the chain by stoppers, unshackle the ends from the swivel and shackle them together.

If the swivel will not go through the hawse, it is desirable to wait for the ship to swing before taking it off the second chain. Thus each chain is a lee chain when it is disconnected.

If it is impracticable to wait for this, handle the riding cable as already described for the lee one, but with extra precautions. The clear-hawse pendant may still be used, but the preventer hawser must be a good one and must be hove taut. The ship in fact rides by this hawser and not by the clear-hawse pendant, while the chain is slacked for unshackling. Steam should be ready, and an officer should be on the bridge ready to work the engines. By giving a turn ahead from time to time the tension on the hawser can be relieved and there should be no danger in the operation.

All working of chain where unshackling is necessary should be done at slack water or as near it as possible.

TENDING SHIP.

When the swivel is not used, it is very important to "tend ship"; that is, to watch the swinging at each turn of the tide, note the direction in which the stern swings, always recording this in the log, and, taking advantage of any conditions which may be helpful, try to make the ship swing to that side which will keep the hawse clear, or clear it if it has already fouled.

It is well to give some attention to "tending ship" even when the swivel is in use. The purpose of the swivel is to prevent the hawse from fouling, but unfortunately it does not always work. It is especially likely to fail if the moor is slack, and in this case the chains may foul so far below water that it will not be known that they are foul until the ship starts to get underway. It is not unusual to find cables very badly fouled when every confidence is felt that they are perfectly clear. *It is very important to watch the swivel while the ship is swinging and to note whether it works or not.* If it does not, it may be practicable to heave it around by a purchase hooked to that part of the chain which should be lifted. To assist in keeping track of the working of the chains, it is a good plan to paint a few shackles of each chain just outside the swivel, using red for the port and white for the starboard cable.

If there is any room for doubt as to the cables being clear, it is a good plan to underrun the riding cable for some distance ahead of the swivel with the bight of a boat chain.

CHAPTER XII.

CARRYING OUT ANCHORS.

§ I.

Important changes have been introduced into all problems connected with the handling of anchors, by changes within recent years in the character of the anchors themselves and in the methods of stowing and handling them.

All ships of recent design carry double-fluked anchors, and the bowers and sheets of this type are, in a great majority of cases, housed in the hawse-pipes, although on older ships one sheet anchor is still carried on an anchor-shelf. Plate (83.) Where this last arrangement exists, an anchor-davit is necessarily provided; and even where all of the anchors house in the pipes, a davit is sometimes fitted, for general convenience in the handling of ground-tackle.

Anchors which stow in the hawse-pipes are not fitted with balancing-links and must be handled by straps. These may be placed at the balancing point, thus serving the same purpose as the usual link, or they may be passed around the crown, where they allow the anchor to hang more or less "ring-heavy." The last arrangement has some advantages, as will be explained hereafter.

Most men-of-war carry "**stream**" and "**stern**" anchors, of from one-fourth to one-third the weight of the bowers. These are not too heavy to be carried out by a single boat, and the problem of handling them presents no great difficulty, provided the method to be used has been thought out beforehand and all the fittings prepared.

It is quite a different proposition to deal with a bower anchor, weighing from fifteen to twenty-four thousand pounds, and stowed without any thought of the possible necessity for carrying it out by boats.

It is held by some seamen that the necessity for carrying out a bower is so unlikely to arise under modern conditions that it is not worth while to prepare for it. In support of this view, it is pointed out that the engines of modern ships are so powerful in comparison with any pull which could be put upon a line for haul-

ing off a stranded vessel, that they are, and must be, the main reliance; and that if they do not suffice there is little hope of accomplishing anything without help from sources outside the ship.

It is true that the main reliance of a ship which goes aground will be upon her engines and upon outside assistance, provided the engines can be used and that outside assistance is available. But the engines can only be used while the stern is tailing off into deep water; and in many, perhaps in most, cases, there is a tendency to swing around broadside on to the beach, when the engines immediately become worse than useless and the problem to be dealt with by outside assistance, if at hand, is of enormously increased difficulty.

As is pointed out in the chapter on "**Stranding,**" the first thing to be done when a vessel goes aground and refuses to back off at once is to hold her from being set farther up by a rising tide, and *to hold her stern off from the beach so that her engines may continue available for use.* Under reasonably good conditions, an anchor of medium weight may suffice for this, but there are many conditions where nothing short of the bower or sheet will answer. It is not here a question of hauling off—the winches would hardly furnish power enough for this—but only of *holding* against wind and tide; although it is by no means unusual for a ship to yield to the steady strain of a taut line and to come off altogether unexpectedly.

If proper preparations have been made beforehand and tested by frequent drills, it should be possible to carry out the stream or stern anchor within ten minutes, and to follow this by a bower within from thirty to forty-five minutes more.

§ II.

First Method. The simplest way to carry out an anchor is to hang it from the stern of a launch as in Plates **108** and **109,** but this utilizes only a part of the floating power of the boat and is not practicable with a very heavy anchor. The weight which can be carried in this way may be much increased by adding weight at the bow, thus counterbalancing the weight at the stern and bringing the boat more nearly onto an even keel. In this way the boat may be made to carry at the stern approximately one-half of its total floating capacity, whereas it would not carry anything like this at one end without a compensating weight at the other.

A convenient way of hanging the anchor and letting it go is illustrated in Plate **108,** where one end of the wire strap is shackled

Plate No. 108.

CARRYING OUT ANCHORS; FIRST METHOD.

to the ring of the anchor, while an eye in the other end engages a slip-hook secured to a ring-bolt in the stern of the boat.

[illegible] In all cases where an eye is formed in a [illegible], the eye must be made large enough to allow the tongue of the slip-hook to run through it freely when released. The eye is better without a thimble.

For a light anchor a manila strap may be used and secured with a toggle as in Plate [illegible].

To provide for weighing, a **weighing-line**, usually of wire, is bent to the crown of the anchor and fitted with a **buoy-rope** and buoy.

The **hauling line**, of manila or wire, is bent to the ring of the anchor and leads to the ship.

Running the Line. With a light anchor it may be assumed that a manila hawser will be used for a hauling line. In this case the end of the line is bent to the ring and the line is payed out from the ship as the boat pulls away, a considerable length of the line, however, being coiled in the sternsheets ready to be thrown out from the boat as the point is approached where the anchor is to be planted. The throwing over of this part of the line at the last gives freedom of movement to the boat at a point where the long bight of the line, dragging astern, would otherwise be embarrassing.

In some cases, with a manila line, it is better to coil the whole length of the line in the boat and carry it out with the anchor, paying it out as the boat returns to the ship after planting the anchor. This is especially convenient when the anchor has to be carried out against or across a strong wind or tide. In this case it is a good plan to let the boat hold on to the anchor after dropping it and to send out another boat from the ship with the end of a 3- or 4-inch manila line, the other end of which is taken to the winch. The first boat can then be hauled back to the ship by the small line, paying out the hawser from the anchor as she comes.

In all cases where any part of the line is carried in the boat, enough of it must be thrown over before letting go, to make it certain that the anchor will reach the bottom with plenty of slack line to spare.

Where a *wire* line is to be run, it is always better to send the end away with the anchor, and pay out the line from the ship, although here, as in all other cases, a few fathoms should be coiled in the boat. The difficulty in dealing with a large coil of wire-rope in the boat is connected in part with its stiffness and its

CARRYING A KEDGE WITH A CUTTER.

tendency to ***kink,*** and in part with its disposition to "take charge" if the stops by which it is being towed should part.

A convenient way to secure the line to the boat when paying out from the ship is shown in Fig. 2, Plate **111.** The stopper used may be either a single line or a span with one part leading to each quarter of the boat.

It is sometimes practicable to take a wire line in a boat, ***on its reel,*** the reel being lashed very securely in place on a temporary platform. The line can then be payed out directly from the reel.

It is important in running a line to head well up against any wind or current which may be setting across, and to remember that the boat will not steer if her stern is bound by a taut line.

If a long scope of line is to be run out, one or more boats should take the weight of the bight, holding it by slip-ropes from the bow and stern ring-bolts.

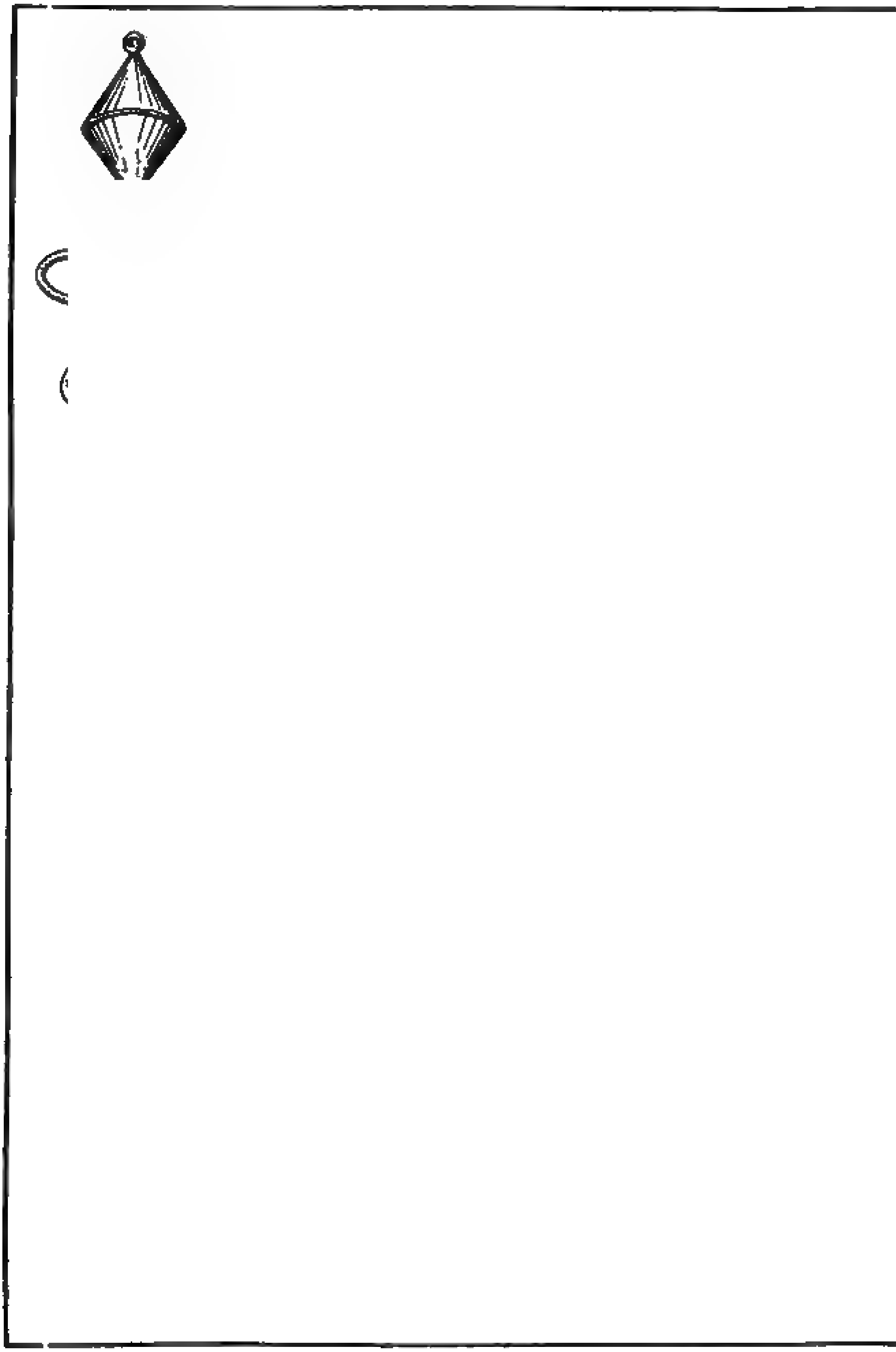
In all cases of carrying out an anchor except when dealing with a light kedge, it is well to *tow* the boat from which the anchor is hung, even though the latter may be a power-boat, as will usually be the case. The reason for this is that a boat carrying an anchor hung over the stern or under the bottom is not free to manoeuvre and will obey her rudder sluggishly or not at all. A still better plan is to lay out a kedge some distance beyond the point where the anchor is to be planted and to haul out by a manila line bent to the ring of the kedge.

Second Method. Plate **110.** This is a very convenient method provided preparations have been made for it in advance. In the British Navy the straps and other fittings are issued to ships and are kept ready for use at a moment's notice.

A "**spreader**" is called for here, to relieve the crushing strain on the sides of the boat. This may rest on blocking, as in Plate **110**, or, if the anchor is not too heavy, on the gunwales of the boat. It is well to lash the spreader to a thwart and also to seize the "**belly-strap**" temporarily to the spreader, taking care to cut the seizings before letting go.

The anchor may be hung by the balancing-link if one is fitted, or better, by a strap around the shank and crown as shown in the plate. With this strap the anchor will hang more or less "ring-heavy," which makes the strap available for breaking out and weighing the anchor, *crown first.*

It is often practicable to break out the anchor and drag it home, crown first, by a line from the crown to the ship. (See § III of this Chapter.)



CARRYING OUT ANCHOR SECOND METHOD.

The **hanging-pendant** must be long enough to reach from the ring under the keel to the water's edge, where it is shackled to the anchor-strap.

The use of the **lowering-rope** between the fish-pendant and the anchor-strap admits of unhooking the fish-pendant after the anchor is lowered into place under the boat.

The **weighing-line** is shackled to the end of the lowering-rope after the fish-pendant is unhooked, or sooner if the eye is large enough.

As the weighing-line will, in most cases, be of wire, a **buoy-rope** is needed for recovering the end.

In all cases like the present one, where the hanging-line from the boat leads off at an angle at the time when it begins to take the weight of the anchor, a strong pull will be exerted dragging the boat *toward* the anchor. This is not necessarily a matter of great importance, but is a factor to be reckoned with. As its tendency is to draw the boat against the lowering-rope, it is well to use a **chafing-spar** alongside to protect the bilge. The launch's mast may conveniently be used for this. Plate **110.**

The **hauling-line** leads from the ring of the anchor to the ship. It is usually bent to the ring and run out with the anchor as has been described in connection with the First Method above. A better way, with a heavy anchor, is to use a **hauling-pendant** on the ring of the anchor, long enough to reach well above water when the anchor is let go. The boat holds on by this pendant (or by a lighter line bent to the eye), and the real hauling-line is sent out by another boat and shackled on. By thus carrying out the anchor and the line separately much trouble is saved.

Ten fathoms is a convenient length for the hauling-pendant, and should answer for all ordinary demands, although it may, of course, become necessary to lay out an anchor in water much deeper than this.

If it is preferred not to let the anchor hang "ring-down," a manila line may be bent to the ring and brought in over the stern of the boat, holding the ring well up under the keel. A 5-inch manila line should be large enough for this, even with a heavy bower. Or the hauling-line may be utilized for this purpose, the bight being stopped up to the boat and holding the ring up.

Of course, if the anchor has a balancing-link it may be handled altogether by this; in which case, however, the weighing-line

must be bent independently to the crown to admit of breaking out the anchor crown first. In this case the lowering-rope and hanging-pendant are shackled to the balancing-link.

In the absence of a balancing-link, the anchor may be balanced perfectly by a strap passed around the shank at the balancing point—which is never more than a few inches from the crown—and held from slipping by a lashing around the crown. No lashing from the ring is necessary as the very short distance which the strap could slip toward the crown would be of trifling importance.

Under ordinary conditions, however, there is no disadvantage in allowing the anchor to hang ring-heavy, supporting the ring if necessary as in Plate **110**; and the arrangement of lines and straps there shown will in general be found convenient.

In dealing with a bower or sheet anchor, it is necessary to provide for unbending the chain. It is convenient to disconnect at the 5-fathom shackle, and to bend the hauling-line to the end of the length of chain which remains on the anchor instead of directly to the ring.

The shackle may be veered outside and handled there or we may bend a wire hawser to the cable inside, just forward of the shackle, take it to the winch and haul taut, after which we unshackle and veer away by the line.

In handling the chain outside, the weight is taken by slip-ropes and jiggers from the forecastle.

It is often very difficult to handle a boat under the bow; as for example, when there is a heavy sea running, or a strong current. Under such circumstances one or more kedges may be laid out and the boat controlled by lines from these, and from the ship.

If the ship is not fitted with an anchor-davit, or if for any reason the anchor cannot be handled under the bow, the **boat-crane** must be used, a heavy block being lashed to the head of the crane and a wire line led through this and taken to the bow, or wherever else the anchor is stowed. If dealing with a bower or sheet, the line is bent to the anchor-strap on the crown, and the anchor is *let go* and hove up to the crane, crown first, where it is handled as may be desired. Under many circumstances this plan is more convenient than any other, even though an anchor-davit is available.

It would probably be practicable under favorable circumstances —everything being quiet under the bow— to take the anchor

directly from the hawse-pipe, as follows: A strap is put on the crown and the anchor is eased down until the crown is awash. The hanging-pendant is brought around the bilge of the boat and shackled to the strap. A large kedge is planted off the bow with a good line for holding the boat clear. A wire-hawser, technically a **veering-line,** is shackled to the cable just forward of the 5-fathom shackle, taken to the winch and hauled taut. The chain is now unshackled and the anchor is eased down by the wire line until it hangs by the crown under the boat.

In lowering away under these circumstances, the force tending to drag the boat toward the anchor and against the chain will be very strong, and a good chafing-spar will be needed to protect the bilge of the boat.

The wire line may be left shackled to the chain from the anchor and be sent out with the anchor as a hauling-line, or it may be unbent and replaced by another line. The length of cable which remains bent to the ring of the anchor takes the place of the lowering-rope and gives drift enough to admit of unbending the veering-line.

Third Method. Plate **111.** This resembles the Second Method, but with the difference that the hanging-pendant slips on the bight of the belly-strap and may thus be made very much shorter, as it can be slipped up to the water's edge, or above, and need only be long enough to admit of convenient handling for shackling to the eyes of the anchor-strap.

As the anchor is lowered away, the eye of the hanging-pendant slips down until the anchor hangs below the keel. It is well to leave the belly-strap rather slack so that the eye may slip down freely.

The spreader is lashed to the thwart and the belly-strap seized temporarily to the spreader as in the Second Method.

To make sure of recovering the belly-strap—which might unreeve after letting go—a light manila **doubling-line** may be passed around under the boat and bent to the ends of the belly-strap.

Fourth Method. Plate **112.** When it becomes necessary to carry out a very heavy anchor, like the bower or sheet of a battleship, the only practicable method is to put two launches alongside and hang the anchor between them from a spar.

Here it is convenient to handle the anchor (stockless) by the ring, bending the weighing-line independently to the crown.

Fig. 1.

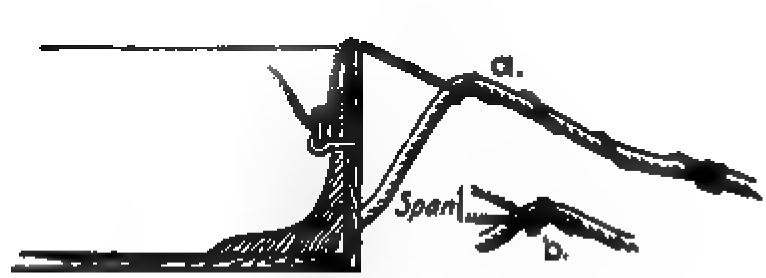


Fig. 2.

CARRYING OUT ANCHORS: THIRD METHOD.

CARRYING OUT ANCHORS. FOURTH METHOD.

Except for this change, the anchor is handled substantially as in the methods already described.

The anchor is eased outside the hawse-pipe until the fish-pendant or lowering-rope can be shackled to the ring. The strap is put on the crown at the same time, and the weighing-line shackled to it. The chain is then veered, and the anchor swings to the fish-pendant.

In the meantime the boats have been prepared and hauled forward and two kedges have been planted where they will give the best control, with a line from each to the bow of one of the boats. A line from the stern of each boat to the ship completes the arrangement for holding the boats stern-on to the ship's side; provided, of course, that conditions make it desirable to hold the boats in this position. In any case, it will be well to have at least one good kedge for holding off, as the drag of the anchor on the hanging-pendant while being lowered into place will be very strong.

Assuming that the boats are held stern-on, the hanging-pendant is passed aft between them and shackled to the ring of the anchor at the water's edge. The chain is then unshackled, as has been described in connection with the Second Method, and the anchor is eased down into position, the fish-pendant passing between the boats, which will have a strong tendency to surge aft in obedience to the drag on the pendant.

The anchor may, of course, be handled by the crown instead of by the ring, without changing any principle of this method, and it will be convenient to adopt this plan if the water is rather shallow.

If the boats cannot be held stern-on, the hanging-pendant must be dipped under the inner boat, as in the Second Method. Here a long pendant will be needed, and the anchor will necessarily hang rather deep. Assuming 10 feet for the beam of the boat, the pendant from the spar to the crown of the anchor would be approximately 16 feet, and allowing 4 feet more for the anchor we have a total depth of 20 feet. As a ship carrying a boat of 10 feet beam would draw at least 28 feet normally, this would probably be all right; but if not, measures must be taken to insure holding the boat stern-on, when the anchor, if handled by the crown, can be hung well up under the boats.

In an extreme case, the water being very shallow, the hanging-spar may be put well aft on the boats (sacrificing something in

flotation), and the boats backed in against chafing-mats on the ship's side, *directly over the anchor,* which in this case must be well below water; the hanging-pendant (not yet passed around the spar) having been already shackled to the strap on the crown.

The hanging-pendant is then passed around the spar, shortened in as much as possible, and secured; after which the anchor is lowered into position where it will hang only just clear of the boats.

In some cases it may be well to drop the anchor from the bow and pick it up on the boat-crane, where it can be held in any desired position, suitable lines for weighing by the crane being bent to the anchor before it is let go, or eased down, from the bow. An anchor hanging from the boat crane can be controlled more easily than by means of any device available at the bow.

The plan shown in Plate 112 for securing the hanging-pendant and letting go is very convenient, but it must be remembered that *unless a turn is taken with the pendant around the spar, the strain on the spar will be approximately double the weight of the anchor,* as the spar will in such a case play the part of a pulley. By taking a turn, this effect is practically annulled.

It is well to make the slipping end of the pendant as short as possible, to avoid the dangerous "whip" which would result from a long end when released.

Steadying-lines may be used from the flukes of the anchor, but must be cast off before letting go.

The plan described in connection with the Second Method for taking the anchor from the hawse-pipe is equally applicable with the present method, subject to the limitations which have been pointed out with regard to the depth of water.

The boats may be towed out by a steamer, or a kedge may be planted beyond the point where the bower is wanted, and the boats hauled out by a line from the kedge. Where conditions are unfavorable, as for example where the boats must be hauled out against a strong wind or tide, it is a good plan to lash a large single block to the ring of the kedge and reeve through this a good manila line, bringing both ends of the line back to the ship. By bending one end to the spar across the bows of the boats or to a span from the bows, and taking the other end on board, the boats may be hauled out by the winch.

DIAMETER IN INCHES OF A ROUND SPAR OF A GIVEN SPAN, TO CARRY A GIVEN LOAD AT THE MIDDLE POINT.

Safe load in pounds.	Span in inches.					
	18	24	30	36	42	48
6,000	6″.8	7″.4	8″.0	8″.3	8″.8	9″.0
8,000	7″.2	7″.9	8″.5	9″.0	9″.5	9″.9
10,000	7″.7	8″.5	9″.1	9″.7	10″.2	10″.7
12,000	8″.2	9″.0	9″.7	10″.3	10″.9	11″.4
14,000	8″.6	9″.5	10″.2	10″.9	11″.5	12″.0
16,000	9″.0	9″.9	10″.7	11″.4	12″.0	12″.5
18,000	9″.4	10″.3	11″.1	11″.8	12″.5	13″.0
20,000	9″.7	10″.7	11″.5	12″.2	12″.9	13″.5

A square beam the side of which is equal to the diameter of a round spar in the above table will support 1.7 times the load of the round spar. Conversely, a square beam to support a given load must have $\frac{6}{10}$ the thickness given above for a round spar.

The preceding table shows the size of spar required to carry a given weight, with a given distance between points of support. There is of course a difference in the strength of different varieties of wood, but the spars which are likely to be available on shipboard are of about the same general character, and the figures here given, which are for good sound pine or spruce, may be used with confidence for all ordinary woods.

The weight which can be carried varies directly with the *cross-sectional area* and inversely with the *span;* that is to say, the distance between points of support. A given spar spanning 24 inches between supports will carry twice as much as if the span were 48 inches.

Safe Floating Power of Navy Boats for 2d, 3d, and 4th Methods Preceding.

Boat.	Floating power.	Remaining freeboard.	
	Lbs.	*Inches.*	
50-foot launch	24,000	28	Load may be safely increased in smooth water.
40 " "	16,000	28	
36 " "	12,000	24	
33 " "	10,000	23	
30 " "	7,500	21	
30-foot cutter	7,000	16	
28 " "	6,000	14	
26 " "	4,500	12	
24 " "	4,100	12	

Safe Floating Power at Stern with Compensating Weight at Bow.

Boat.	Load at stern if bow is loaded.	Load at forward end of boat.	Number of men required at forward end.	Approximate remaining freeboard at stern.
	Lbs.	*Lbs.*		*Inches.*
50-foot launch . .	12,000	12,000	90	24
40 " "	8,000	8,000	65	24
36 " "	6,000	6,000	45	20
33 " "	4,500	4,500	35	18
30 " "	3,000	3,000	22	16
30-foot cutter	2,500	2,500	18	13
28 " "	2,000	2,500	18	11
26 " "	1,500	2,000	15	9
24 " " . . .	1,000	1,500	12	9

The weights in the bow should, if possible, be men, and these should be grouped as far forward as is practicable. When the anchor is let go, the men must be prepared to move quickly aft, as the bow will dip suddenly.

§ III.

To Pick Up an Anchor.

Where an anchor has been carried out for any purpose, it may be assumed that a weighing-line has been bent to the crown either as described in the preceding section or in some other efficient way. In this case the simplest way to pick up the anchor is to run a line from the ship to the end of the weighing-line and drag the anchor home crown first and run it up to the hawse-pipe. This plan very greatly simplifies the matter of using an anchor for such temporary purposes as hauling the stern around for bore-sighting, for sub-caliber target practice, or for improving ventilation in a tropical climate.

If conditions are such that the anchor cannot be hauled home by the ship, it must be weighed by a boat, and this will not be very difficult if the anchor is of moderate size, and if it can be broken out by the crown. If no line has been provided from the crown, a diver should be sent down to bend one on.

To Weigh an Anchor by a Boat. An anchor of medium size may be weighed by a boat by bringing the line in over the stern roller and applying a purchase of any convenient kind; a luff upon luff, an improvised windlass, or any other device which may be suggested by the conditions. The flotation of the boat

can be utilized to start the anchor, a convenient way being to fill the stern-sheets with men and heave the line well taut, then to shift the men forward to the bow. By letting them "sally" forward on the run, the anchor may sometimes be jumped out. It is only necessary to lift the anchor far enough to admit of carrying it back to the ship.

If there is no weighing-line from the crown of the anchor, and if circumstances do not admit of sending down a diver to bend one on, the anchor must be broken out by the ring. In such a case it is especially important to use a line from the ship, although a small anchor can, of course, be handled, even in this way, by a good-sized launch. A battleship's launch, for example, should be able to deal with a 3000-pound anchor very easily, and in some cases—when the anchor is not holding very strongly—with one of double this size; that is to say, with the "stream" anchor which is now supplied to all battleships.

In cases of especial difficulty it might be well to put two launches alongside, connecting them with a spar as in Plate **112**, and make use of their power of flotation by loading them deeply with men, hauling taut the line from the anchor to the spar, and then removing the men. Two 40-foot launches, holding 100 men each could be made in this way to exert a pull of 40,000 pounds.

LOST BOWER OR SHEET.

Where a bower or sheet anchor has been lost by the parting of a cable, the problem is quite different from that of dealing with a lighter anchor such as might have been carried out by the ship's boats.

Here it will usually happen that a certain length of chain is attached to the anchor. The problem is, in this case, for the ship to get hold of this chain and weigh the anchor with her windlass. This means, first of all, that the ship must place herself near the anchor, but of course not close enough to interfere with working lines from a boat. If the anchor is buoyed, it is located without difficulty. If not, it must be found, and the easiest way to find it is to drag for the chain across the line on which it is supposed to lie. A grapnel may be used for dragging but it is better to take a kedge anchor, to the stock of which a capstan-bar is lashed to keep the fluke down.

The chain having been grappled, it may be possible to lift the bight or the end and bend on a line from the hawse-pipe, by which the ship can haul over at once and pick up the anchor. For this the boat that has found the chain would lift the bight or hold on by the grapnel and send down a diver to bend a 6-inch or 7-inch manila line to the chain near the end. Such a line should answer for lifting the chain and probably for hauling the ship into position, but it would not weigh the anchor. If the chain is not long enough to admit of bringing the end inside the hawse, the end of a good wire line is sent out to the boat and shackled by the diver to a link near the end, but not to the end link.

Where the anchor to be dealt with weighs upward of ten tons, as do the bower and sheet anchors of a superdreadnaught, it is out of the question to weigh it with any line which could be handled by a diver. The heaviest manila hawsers supplied to ships are 10 inches in circumference and are not strong enough to break out the anchors in question. Nor could any diver hitch a line of this size to the crown of an anchor. A wire hawser would be strong enough, but wire does not work well on the nigger-head of a winch.

The following plan combines several advantages. It provides a perfectly manageable wire line to be shackled (not hitched) to any part of the anchor that can be reached. It provides a length of chain-cable for shackling to the ship's cable, belonging, it may be, to the lost anchor, and it provides an ample length of manila hawser for weighing the cable and the wire and for hauling the ship into place over the anchor. The plan is as follows:

A 5-fathom shot of chain is shackled at one end to a pennant of 4½-inch wire eight or nine fathoms long, and at the other end to a 6 or 7-inch manila hawser. The shot of chain and the wire pennant are slung outside a motor sailing launch, the manila line is coiled in the stern sheets, and the boat proceeds to a point near the anchor. Here enough of the manila line is thrown over to reach the bottom, the chain is paid down on top of this, and lastly the wire pennant is paid down on top of all, where it is easy for the diver to handle it; the diving boat gets into position, and the diver goes down and shackles the wire pennant to any part of the anchor that he can reach conveniently.

The motor-sailer takes the manila line back to the ship and it is hauled in through the hawse-pipe and taken to a winch.

The ship manœuvres into a position as nearly over the anchor as is practicable, and heaves in the line. When the chain comes in it is shackled to the free end of the cable on board and the anchor is hove up and hung by a stopper, after which the cable is bent to the anchor in place of the wire pennant.

If the water is too deep for diving, and if the chain is not long enough to be picked up by grappling, the chances of recovering a *stockless* anchor are hardly worth considering.

With an old-fashioned anchor the case is quite different. Here we may hope to catch the upper fluke by dragging the bight of a light chain, or of a rope weighted at two or more points, across the place where the anchor is known to lie. When the fluke is caught, a shackle may be put around the two parts of the dragging rope and allowed to slip down, binding them so that they cannot become disengaged.

If the anchor is not buoyed, we may assume that its position can be fixed within narrow limits by bearings, and the first thing to be done will be to locate it exactly and to mark it by a buoy.

We then proceed as before, utilizing a diver if practicable, or dragging for the bight of the chain.

NOTE.—In all cases of dragging for an anchor or a chain, it is important to mark by floats the area covered as the work progresses.

CHAPTER XIII.

THE STEERING OF STEAMERS.

§ I. TERMINOLOGY.

The United States Navy has in recent years adopted a new terminology in connection with the steering of ships, substituting "Right Rudder" for "Port Helm" and "Left Rudder" for "Starboard Helm." There is a certain inconvenience resulting from this change, due to the fact that the older terms continue in use in other Navies and in the Merchant Service. The change is, however, logical and reasonable. When the operation of steering was a matter of actually putting the helm (tiller) to port for swinging the ship's head to starboard, it was natural and reasonable that the command should coincide with the act to be performed, even though it was as true then as now that the governing influence in the movement of the ship was the starboard rudder, not the port helm. But in a modern ship, not only is it true that the rudder and the ship's head both go to starboard, it is true that the steering wheel (or lever) also goes to starboard. And it is certain that the helmsman gives no thought to the fact that (possibly) somewhere in the remote recesses of the ship, his action in moving the wheel to starboard has caused a tiller to move to port.

In this and succeeding chapters, the terms "Right Rudder" and "Left Rudder" have been adopted, with a footnote indicating the older (and commoner) terminology where this is considered necessary.

§ II. SINGLE SCREW.

The elements which enter into the steering of a screw steamer are so many, and their effects are so varied and conflicting, that any attempt at an exhaustive analysis of them would be altogether out of place in a work on practical seamanship. It is proposed here merely to name and briefly discuss the most important of them and to explain such of their effects as enter prac-

tically into the handling of a ship. In this discussion it will be assumed, where not otherwise stated, that all conditions are normal and average; that is to say, that the ship is of medium size and draft and loaded to her mean water-line; that she has no unusual features of design; that she draws rather more water aft than forward; that her rudder is of the ordinary type and of medium size, and fitted to a rudder-post immediately abaft the propeller-well. It will be assumed also, except where the contrary is stated, that the weather is calm.

For simplicity, the discussion will be confined to a right-handed screw, so that all which is said of the effects of the screw upon the steering must be exactly reversed for a vessel with a left-handed screw.

Twin-screws will be treated in a separate section.

The factors which we shall consider as entering into the steering of a steamer are the following:

1. The ordinary direct influence of the Rudder.

2. The Screw Current,—which we shall find to be made up of two distinct parts.

3. The Force exerted by the revolving blades of the Screw to drive the stern to one side or the other by their direct Sidewise Pressure upon the water.

4. The Wake Current.

1. THE RUDDER.—The effect of this is simple and well understood. It calls for no explanation here, except in so far as it is complicated by the screw current, in connection with which it will be fully treated below.

2. THE SCREW CURRENT.—As the screw turns, it draws in a current from one direction and forces it out in the other. In going ahead, the current is drawn in from forward and forced out aft. In backing, it is drawn in from aft and forced out forward.

It is found that the in-rushing "suction" current may be considered as flowing parallel to the line of the shaft, but that the current driven off from the screw partakes to an important degree of the rotary motion of the blades and moves diagonally to the shaft and keel.

(a) If the screw is turning ahead, the inflowing

suction current from forward moves along the lines of the run toward the screw and has no appreciable effect upon the steering.

It is different with the outflowing current thrown off and driven aft by the screw. This current, by reason of the rotary motion which has been referred to, strikes diagonally upon the rudder-post and the rudder (which we will for the moment suppose to be amidships) and exerts a distinct force tending to throw the stern to one side. We must recognize here, however, two factors opposing each other. The upper blades of our right-handed screw move over from port to starboard and drive their current against the port upper side of the rudder-post and rudder. At the same time, the lower blades drive in their current upon the starboard lower side. As the lower part of the rudder is commonly larger than the upper part, it is natural that the current from the lower blades, tending to drive the stern off to port, should more than overcome that from the upper blades, and that the resultant of these two forces should tend, upon the whole, to move the stern to port (in going ahead, with helm amidships). The conclusions of theory in this matter are confirmed by an interesting experiment in which the rudder was divided into two parts by cutting it horizontally. With the two parts left free to move and the screw turning ahead (the ship being at rest), the upper part took up a position at an inclination of nearly 10° on one side of the keel, while the lower part stood at an equal angle on the other side. In other experiments, where the full rudder was left free to move under the influence of the screw current alone, it took a position at a small but distinct angle with the keel on the side toward which the current from the lower blades tended to deflect it.

If the rudder, instead of being kept amidships, is put over to one side, the sternward velocity of the current will have its effect, as well as the rotary velocity.

With the ship and screw both going ahead, this part of the current will add its effect to the ordinary steering effect of the rudder, and simply produce a greater turning force than would otherwise exist. It may happen, however, that the screw is moving ahead and sending its current aft against the forward side of a hard-over rudder, while the ship is moving astern and developing its ordinary effect upon the after side. This is the case when a ship, while moving astern with some velocity, suddenly

puts her helm hard over and throws her engines full speed ahead. This case, which is one of special importance, will be treated at considerable length in a later section.

(b) *If the screw is backing*, it draws in a current from aft and forces it out forward, where it strikes against the sides of the afterbody with the diagonal velocity given by the rotary motion of the blades. In this case, the "suction" current, coming from aft, will have no effect as long as the rudder is amidships, since its motion is parallel to the keel; but if the helm be put over to either side, this current assumes great importance and may even become the controlling factor in the steering of the ship. So long as the ship is moving astern, this factor acts with the ordinary resistance of the water and simply increases the rudder's turning power. But in the case where the engines are suddenly backed while the ship has headway, this "suction" current opposes and reduces the natural steering power of the rudder, and may altogether overcome it and throw the ship's head to the opposite side from that to which the rudder would throw it under ordinary conditions. This case is the converse of that described under (a) and is one of the most important with which we shall have to deal in the later sections of this chapter.

We have now to consider the effect of that part of the screw current which, in backing, is thrown off from the screw and driven forward against the afterbody of the ship. Since this current partakes of the rotary motion of the screw, it will strike the stern at a considerable angle to the keel line and will produce a pressure tending to force the stern off toward the side to which the blades are moving. It is clear that the upper blades of our right-handed screw will be moving over from starboard to port and sending their current against the upper starboard side of the stern, while the lower ones send theirs against the port side in the neighborhood of the keel. We have thus two forces acting against each other; but a little consideration of the shape of the stern and the position of the screw will make it clear that the upper blades are much more favorably situated than the lower ones, so far as this effect is concerned, and that we may fairly expect their current to prevail over that from the lower ones. Not only are they closer to the body of the stern, but they drive their current against it at a much more effective angle,

owing to the fullness of the upper, as compared with the lower, run. We might then expect that the effect of this part of the screw current would be, upon the whole, to force the stern to port; and this is found to be the case in practice.

If the helm be kept amidships, so that the effect of the rudder is eliminated, the stern of a right-handed screw steamer, in backing, works off to port. It does not follow that this is entirely due to the screw current, for we shall find that the factor we are next to consider—the sidewise pressure of the blades—may have much to do with it; but experiments show that the screw current is an important factor in the matter and that its action is as above described.

3. THE SIDEWISE PRESSURE OF THE SCREW BLADES.—As the blades revolve, they exert a force tending to drive the stern off to the side opposite that toward which they are moving. Since the upper and lower blades move toward opposite sides, we have here two forces acting against each other which would exactly balance but for the fact that the lower blades, moving under greater pressure than the upper ones, meet with greater resistance and exert a greater force. The result is that the pressure of the lower blades preponderates; and in any given case, the stern tends, so far as this element is concerned, to work off to the side from which the lower blades are moving. In going ahead, then, the tendency of the stern is to starboard, whereas in backing, it is to port.

It is found that this factor is not of great practical importance under ordinary circumstances, but that it becomes so whenever, from imperfect immersion or from any other cause, the upper blades "churn" the surface water. It is a fact of every day observation that when a steamer is starting from rest, either going ahead or backing, the screw, even though well immersed, usually "churns" more or less until the ship has gathered way. Under these circumstances, therefore, this factor has maximum effect. Its effect is also important even when the ship has way, if the upper blades are only partially immersed. The fact that it does not count when the ship has headway and when the screw is well immersed is due to the factor which we have next to consider.

4. THE WAKE CURRENT.—This is a current which the ship carries with her as she moves ahead through the water, by reason

of the friction between the water and the hull. The body of water involved in it extends to a considerable distance on either side, but attains its maximum volume and velocity immediately under the stern; that is to say, in the vicinity of the screw and the rudder; where it breaks up the water, and, by its forward velocity, materially adds to the pressure on the upper blades of the screw. It is essentially a surface current, and experiments show that it decreases as the depth of water increases and that, at the level of the keel, it is practically imperceptible.

It is difficult to assign any definite value to the velocity of this current, but it has been assumed in certain investigations by Professor Rankine at 10 per cent of the speed of the ship. It enters into our problem only in cases where the ship is moving ahead.

The effect of the wake current upon the rudder is to reduce the steering power. Its effect upon the screw is to increase the resistance to be overcome by the upper blades, and thus to offset the advantage of the lower blades in direct turning effect due to the greater depth in which these blades move.

We proceed now to consider the effect of the elements which have been described, upon the behavior of a steamer under various conditions.

This subject will be treated under the following heads:

1. Ship and Screw going Ahead.
2. Ship and Screw going Astern.
3. Ship going Ahead, Screw Backing.
4. Ship going Astern, Screw going Ahead.

SHIP AND SCREW GOING AHEAD.

Here the rudder is the great controlling factor, and the problem of manœuvring under these conditions may be treated practically with very little reference to the effects of the screw. It would not be exact to say that these effects are wholly inappreciable, for there are conditions under which they become clearly apparent; but they are rarely important and it would be almost impossible to lay down satisfactory rules with regard to them. All that need be said of them may be summarized as follows:

If the rudder is kept amidships, the screw has a slight tendency to throw the head to port while the ship is gathering way and moving slowly ahead. As the speed increases, this tendency gradually disappears and at medium speeds the screw seems to have no steering effect whatever. Finally, at high speeds, there seems to be with some ships a slight tendency of the head to starboard.

If the rudder is put over to either side while the screw is turning but before the ship has gathered way, the discharge current from the screw exerts a powerful steering effect, driving the stern off exactly as if the ship were moving ahead; and this effect continues in a gradually decreasing degree as the ship gathers way and works up to the speed which is properly due to the revolutions of the screw at the time. Thus, if the rudder is put to the right, and the screw started ahead with a number of revolutions corresponding normally to a speed of ten knots, the head will turn at once to starboard, as if the ship were moving. As the ship gathers way, the steering effect of the screw gradually falls off and is replaced by the normal steering effect of the rudder for headway. We may put this differently by saying that the steering effect of screw current is due to the "slip" of the screw.

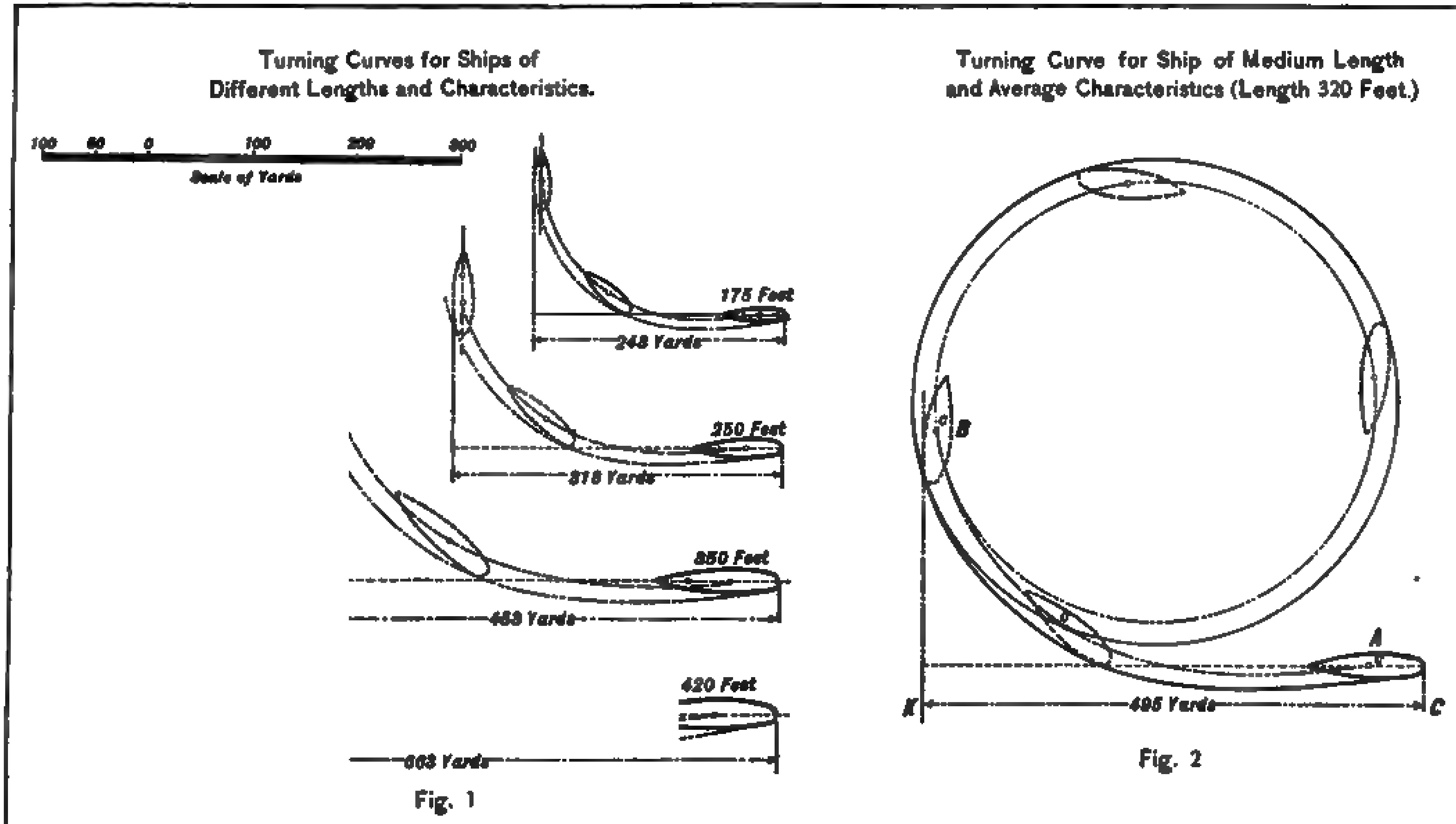
We proceed to consider the steering of a ship when steaming ahead, as affected by the rudder alone; beginning with the case in which the ship, while running at fair speed, puts the helm suddenly hard over, without reversing or stopping the engines. This case presents certain points the examination of which will be helpful in dealing with other cases to be taken up later.

In Plate 113 are shown the curves traced out in this way by a number of ships of widely different types. Some of these ships had twin-screws, but it is found that so long as both screws are kept turning ahead, there is no important difference between the curve of a single screw and that of a twin-screw ship.

It will be noted that, the helm being put hard over as rapidly as possible (position A), the ship begins to turn at once and turns with increasing rapidity up to about the point B, from which point onward she turns uniformly in a path which is practically a circle. As she swings around the circle, her bow points steadily

"Right rudder" is port helm.

"Left rudder" is starboard helm.



TURNING CURVES.

inward while her stern sweeps out a circle considerably larger than that traced by her bow. She does not, that is to say, follow her own keel line, but presents her bow and side to the water through which she moves.

The first effect of putting the rudder over is to throw the whole mass of the ship off to leeward, so to speak; that is to say, to the side opposite that toward which it is desired to gain ground. The stern goes off most; but the whole ship, except the extreme bow, is thrown more or less to this side, and some experiments have semed to show that even the bow goes off at first.

The ship ranges ahead nearly along the line of her original course, but slightly to leeward of it, for a distance which may be roughly stated as from two to three ship's lengths, before she commences to gain ground in the desired direction.

> The momentum of the ship along her original course persists for a time and drives her on along this line in spite of the forces which are turning her head away from it.

The stern does not finally clear the line of the original course until it has covered from two to three lengths measured along that line. In the meantime, the ship's head has changed by more than three points.

The salient features of the turning curve are the following:

The Advance. The distance gained parallel to the original course at that point of the curve where the tangent to the curve has swung through 90° from the original course.

The Transfer. The distance gained to the right or left of the original course at that point of the curve where the tangent to the curve has swung through 90° from the original course. (In British nautical literature, the tactical diameter is called the transfer.)

The Tactical Diameter. The distance gained to the right or left of the original course at that point of the curve where the tangent to the curve has swung through 180° from the original course.

The Final Diameter. The perpendicular distance between the tangent to the curve at the point where it has swung through 180° and that where it has swung through 360°.

The Drift Angle. The angle at any given point of the curve, between the tangent to the curve and the heading of the ship.

The Kick. The sweep of the stern toward the side away from the rudder when the rudder is put over to begin the turn.

The Pivoting Point. The point in the length of the ship about which the ship swings as on a pivot when the rudder is put over. The position of this point depends upon the build of the ship and especially upon the comparative draft forward and aft, and upon the distribution of weights. It may be assumed for the average ship as located from one-fourth to one-third of the length of the ship from the bow. Where the draft forward is much greater than aft and where the rudder is large, the pivoting point is farther forward and in an extreme case it may be actually at the bow or even a little ahead and outside of the ship.

All of the above features are brought out in a very striking way in the turning curve of the *Yashima,* a ship of very exceptional manœuvring power, built many years ago for the Japanese Navy (Fig. 1, Plate 114). Although the *Yashima* is out of date as a fighting ship, the characteristics of design and manœuvring power which are here illustrated are as interesting and instructive as ever.

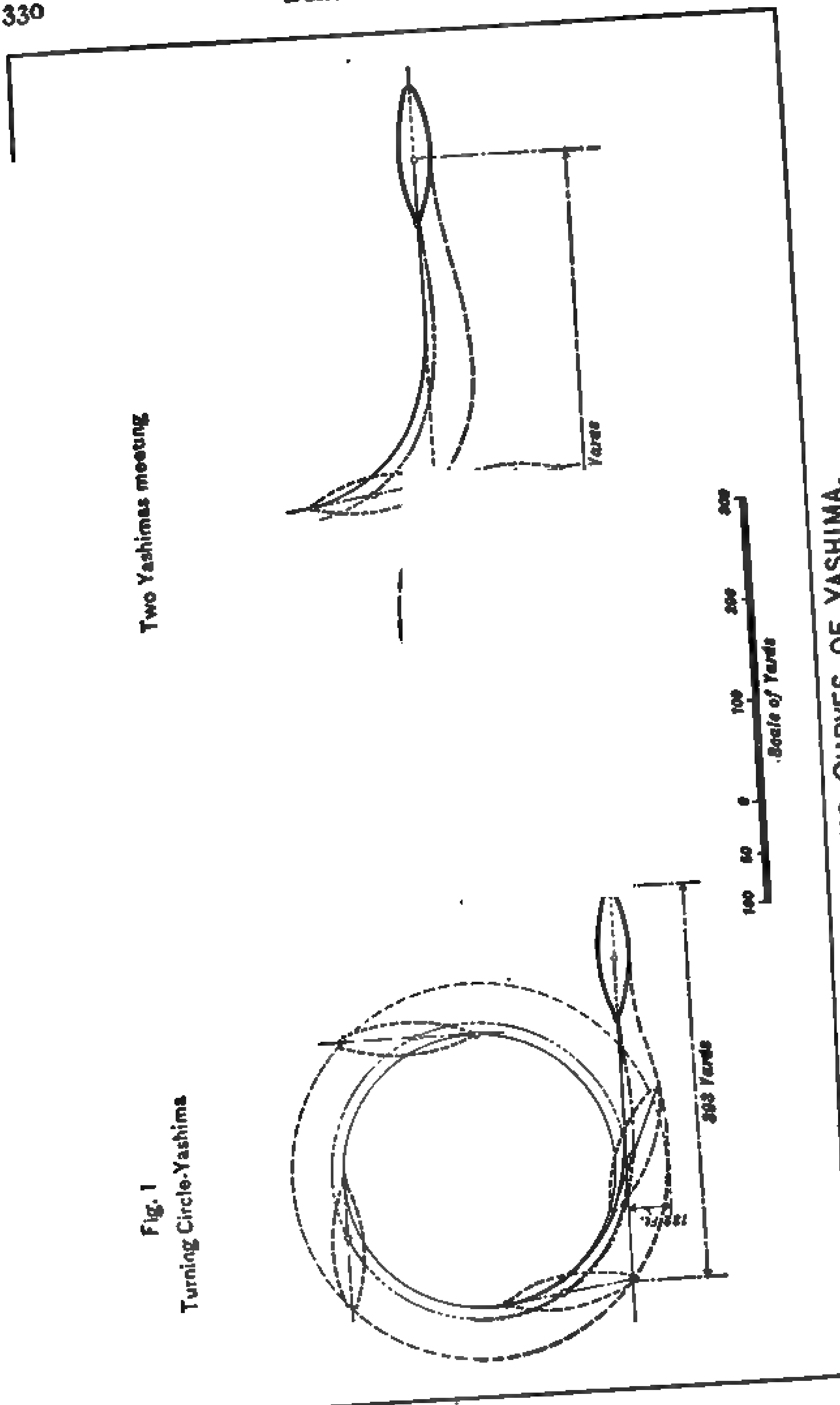
The features which have been noted in the other curves are all present here in an exaggerated form. It will be seen that if two *Yashimas,* sighting each other dead ahead, should put their rudders hard over while separated by a distance of 650 yards (5 ships' lengths) their sterns would collide (Fig. 2, Plate **114**).

The remarkable manœuvring power of the *Yashima* is due to the fact that her after deadwood is cut away to a very unusual extent. This reduces the resistance of her afterbody to lateral motion, and as a result the stern is thrown off much more rapidly and to a greater distance than would ordinarily be the case. This illustrates very strikingly the fact that *it is the stern and not the bow of the ship that moves in turning.*

Plate **115** shows the curves of the super-dreadnought *New Mexico,* recently added to the United States Navy.

With regard to the speed involved in these curves, this begins to fall off, as might be expected, the moment the rudder is put over, the reduction being due to the resistance of the rudder and the sidewise motion of the ship. It continues to fall off until the point is reached where the turning curve becomes uniform and

Plate No. 114.



TURNING CURVES OF YASHIMA.

circular, at which point it has fallen off to something like 60 per cent of its original value. From this time on, it remains constant as long as the turn continues with the same rudder angle.

It is found that the speed at which a ship is moving when her rudder is put over does not greatly affect the space in which she will turn. A ship running at ten knots speed, putting her rudder over suddenly, follows very nearly the same track as if she were running at twenty knots. This is a result which would perhaps hardly have been anticipated, but it has been demonstrated by too many experiments to be called in question. As regards the *time* of turning, there is, of course, a great difference in favor of high speed.

It follows that if a ship is attempting to clear a stationary object by putting her rudder hard over, it makes little difference with regard to her success whether she slows or continues at full speed, though it will make much difference in the force with which she strikes, if strike she must. If the object to be avoided is another ship under way, there will be an advantage in gaining time by slowing, as this will give an opportunity for both ships to recognize the situation clearly and to act accordingly. It is important to remember, moreover, that *during the time actually occupied in putting the rudder over,* a steamer running at high speed will cover a greater distance than if she were running slow.

We do not here deal with the question of reversing the engines. This will be considered in a later section.

We have thus far confined our attention to the effects of a rudder put suddenly hard over. This is an exceptional case, but it brings out very clearly the points that are involved in the more common case in which a small angle of rudder is used—generally for a short time only—and a small change of course effected. In this case, also, the stern is thrown off, and for some time the body of the ship moves along a line to leeward of the original course. This should always be taken into account. It becomes of great importance when manœuvring in crowded waters, and in all cases where the danger to be avoided is close aboard. *The realization that the stern moves and not the bow, will often make all the difference between a close shave and an inevitable disaster.*

We have seen that the effect of speed upon the space in which a ship will turn with a given angle of rudder is not great. It

should, however, be remarked, that a fair speed is essential for the proper handling of any ship. Not only is a ship when moving very slowly through the water at the mercy of the wind and sea and tide, which under such circumstances have an undue effect upon her, but all the varying and conflicting elements that have been described in § I are liable to manifest themselves in unexpected and seemingly erratic ways. It is therefore important always to keep up a reasonable speed; and while this term is hardly susceptible of exact definition, it will probably be agreed that such a ship as we are at present considering—of average size and manœuvring powers—will not handle with certainty at speeds much below four knots.

We shall discuss in another chapter the theory held by many seamen, that it is safer to run at maximum speed through a fog than to slow down.

Although it is found, as has been explained, that when a ship is going ahead, the rudder so far outweighs all other elements involved in the steering that these other elements may in general be neglected, it is nevertheless true that hardly any ship turns with exactly the same readiness to port and to starboard; and it appears from experiments to determine the tactical diameter of men-of-war that the circle made in turning to starboard may differ from that in turning to port, by as much as ten per cent.

Although we are dealing at present with the *turning* of ships, it may be well to add a word with regard to the power of *stopping*.

It is found that a ship with reciprocating engines steaming ahead with the rudder amidships, and suddenly reversing her engines without moving the rudder, will stop in from three to five times her own length; and that this distance is practically independent of the size and speed of the ship.

This supposes the same power used in backing as in going ahead. If there is a reserve of power available for backing, a ship should be stopped in twice her length.

The space in which a ship can be stopped, as compared with that in which she can be turned, becomes important when danger is suddenly discovered ahead and on both bows; as, for example, when a ship finds herself heading for a coast or a line of reefs, and dangerously close. We have seen that she may, by putting her rudder hard over, turn through eight points with an "*advance*" in the direction of the original course, of about four lengths. This would seem to show that it is at least as safe for a

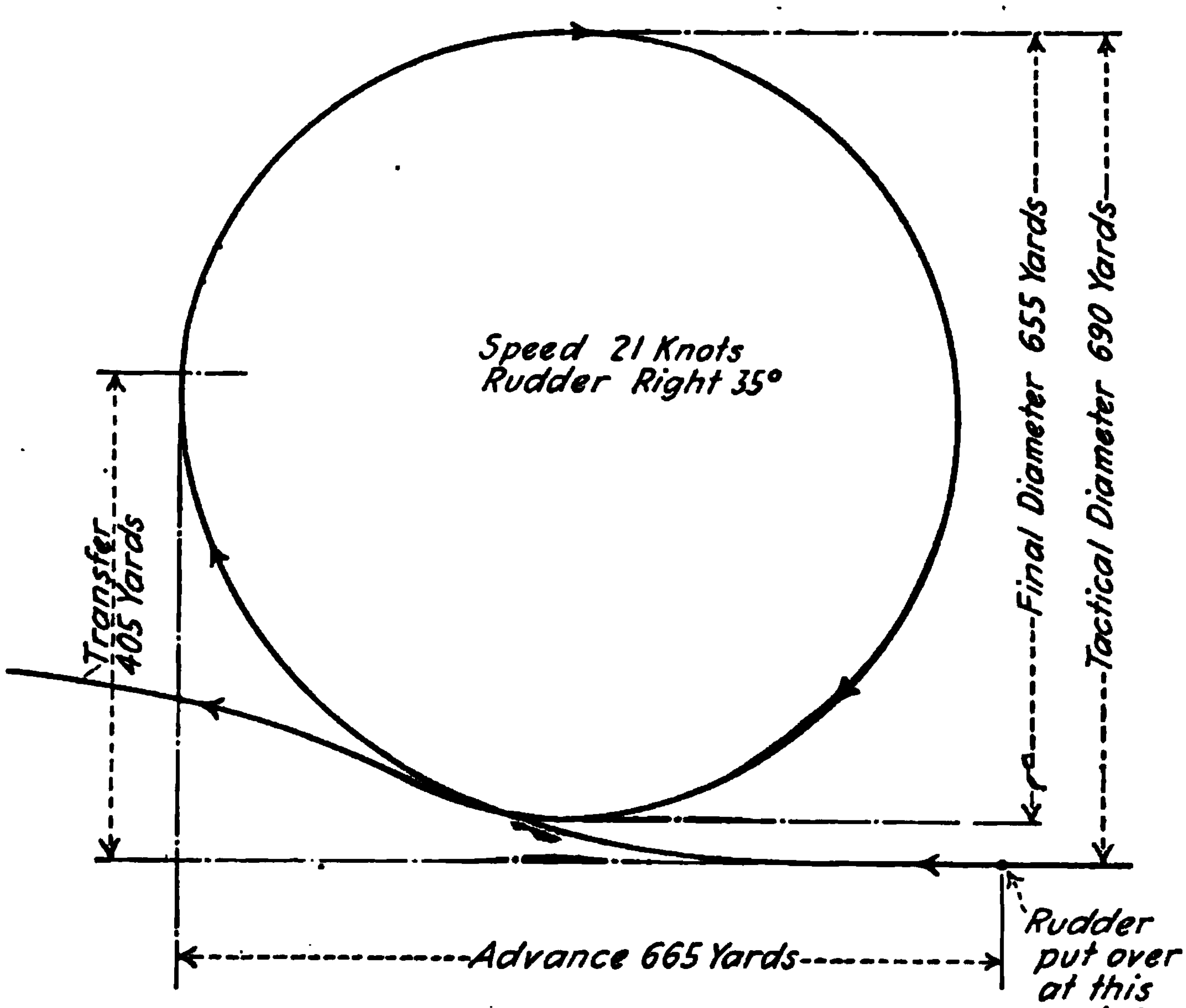


FIG. 1

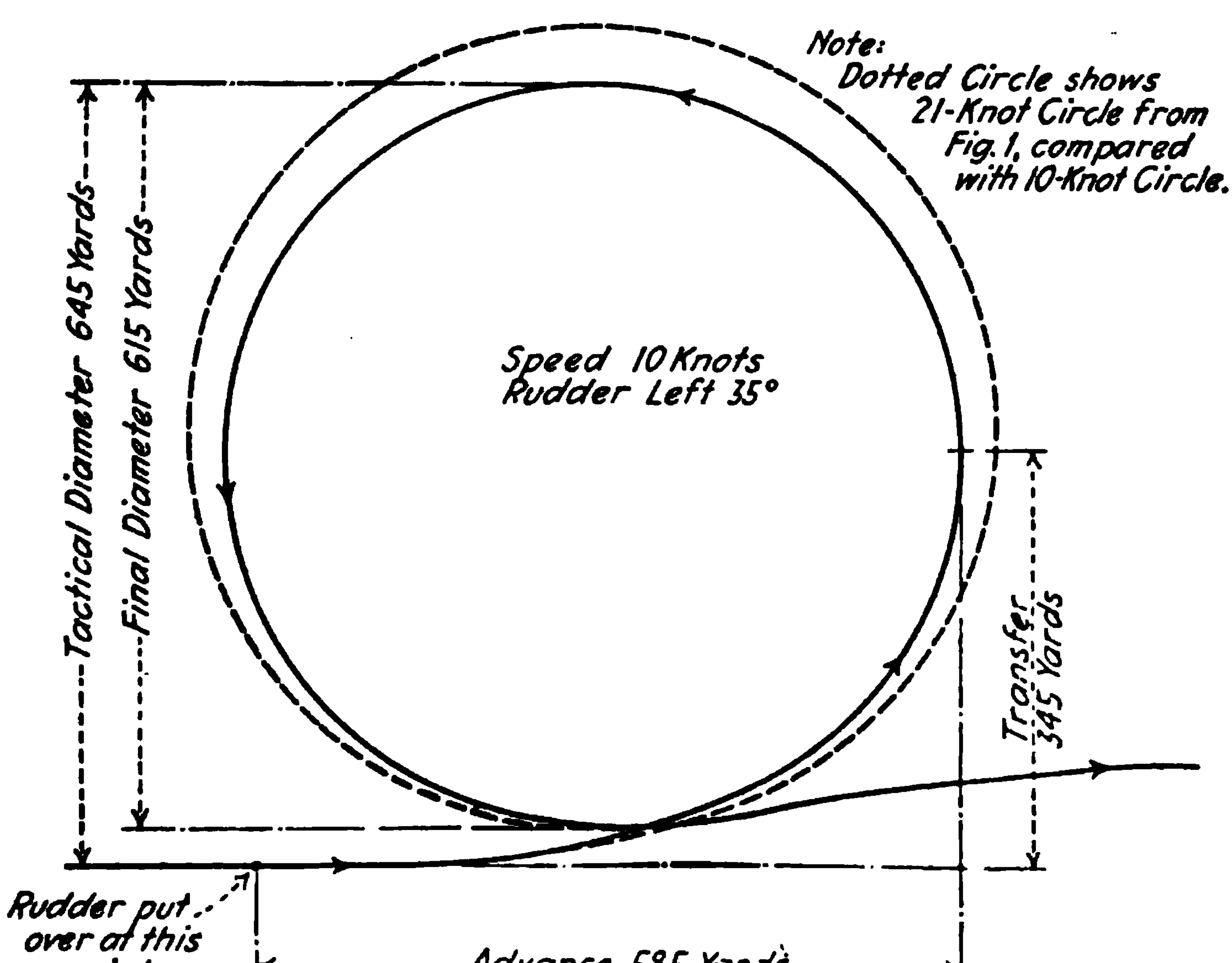


FIG. 2

TURNING CIRCLES, U. S. S. NEW MEXICO.

single-screw steamer to try to clear such a danger by means of the helm, as by stopping the ship.

This was the conclusion of the Committee of the British Association (see Report British Association 1878, page 422).

It will be shown later that probably the safest course of all is to combine both methods, putting the helm hard over (preferably to port), and when the head has begun to swing decidedly, reversing full speed and immediately *afterward* shifting the helm.

The time and space in which a ship may be brought to rest when moving at a given speed are matters of great practical importance. The time may be determined by the very simple experiment of reversing the engines and noting the number of seconds required to come to rest. Observations upon the space are not so easily made, but experience shows that the space may be determined with considerable accuracy from the observed time, by the simple formula:

$$D = 7/10\ ST.$$

Where $D =$ Distance in feet required to stop.
$S =$ Speed in knots and tenths.
$T =$ Time in seconds (observed).

For turbine ships the distance and time required to stop by backing the engines are approximately doubled.

SHIP AND SCREW GOING ASTERN.

(Plate 116.)

This case is more complicated than the preceding one, for the reason that the effects of the screw, which in going ahead are so far overpowered by those of the rudder that they may usually be neglected, become, in backing, quite as important as those of the rudder, and in many cases much more important.

The forces involved in the steering of a steamer in backing are:

1. The Sidewise Pressure of the Blades, driving the stern to *port.*

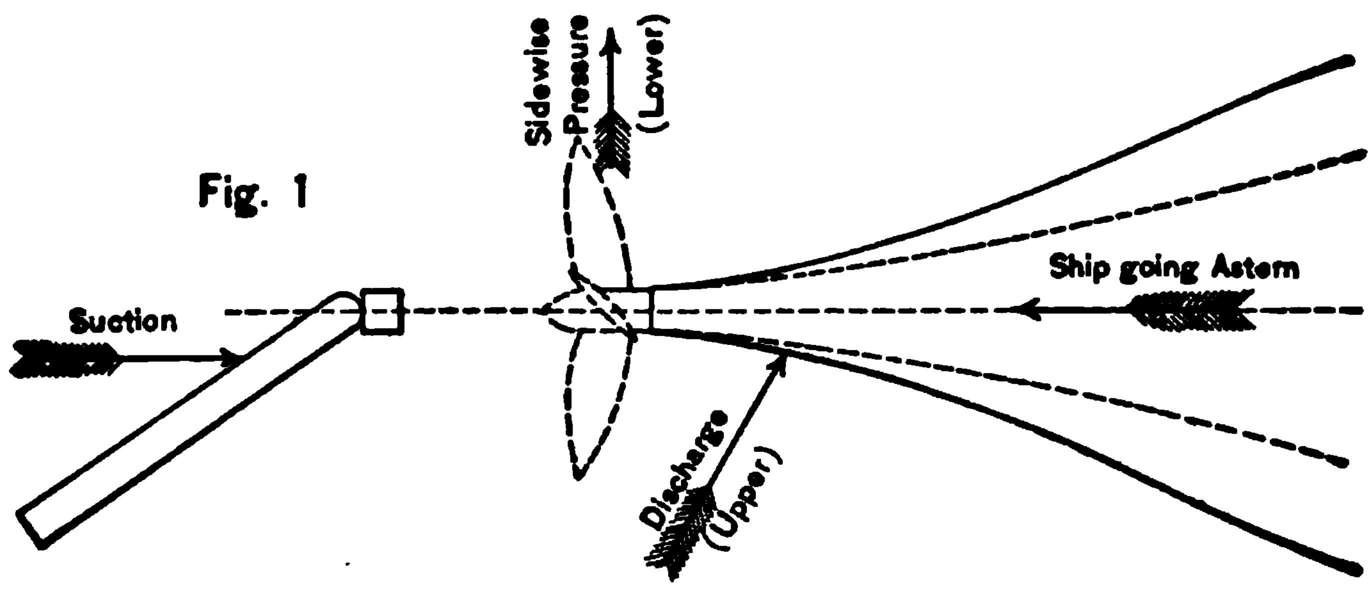
2. The "Discharge" current, thrown forward and inward from the screw, against the sides of the run, and tending also to drive the stern to *port.*

3. The "Suction" current, drawn in from aft against the after side of the rudder, and acting to throw the stern to starboard or to port according to the way the helm is put. This factor does not enter into the problem with the rudder amidships.

4. The ordinary steering effect of the rudder, tending to throw

Ship and Screw going Astern. Ship beginning to back.

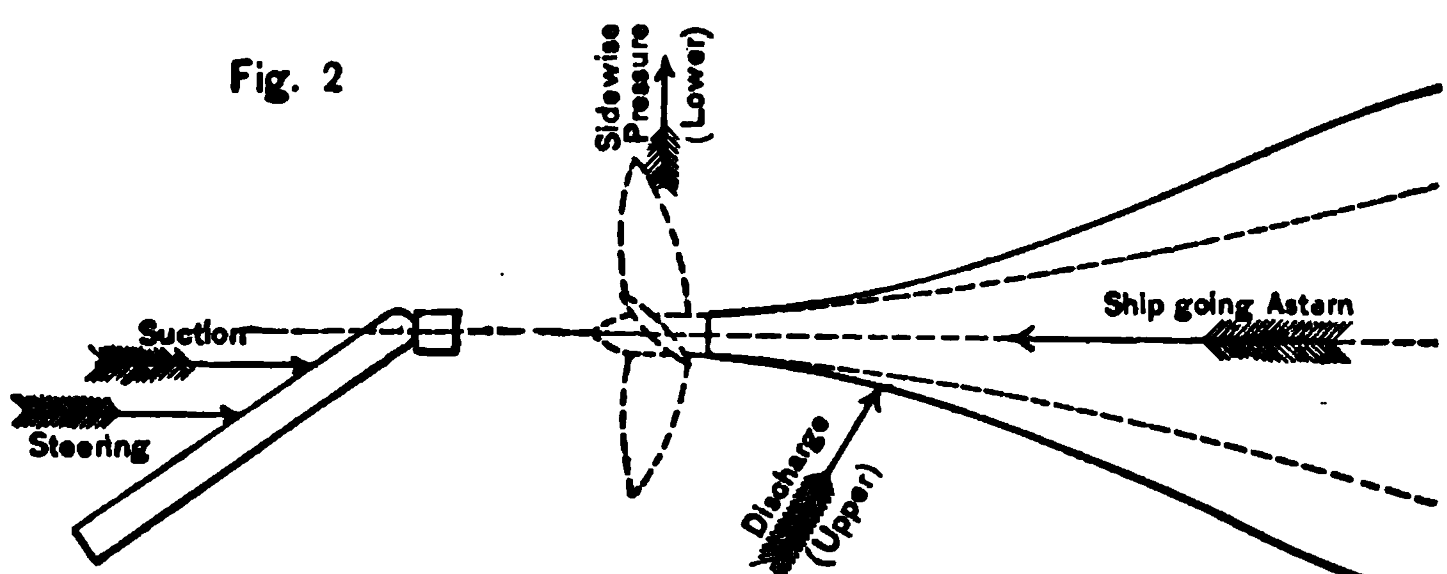
Fig. 1



Stern usually goes to Port, Head to Starboard.

Ship and Screw going Astern. Ship Moving Astern.

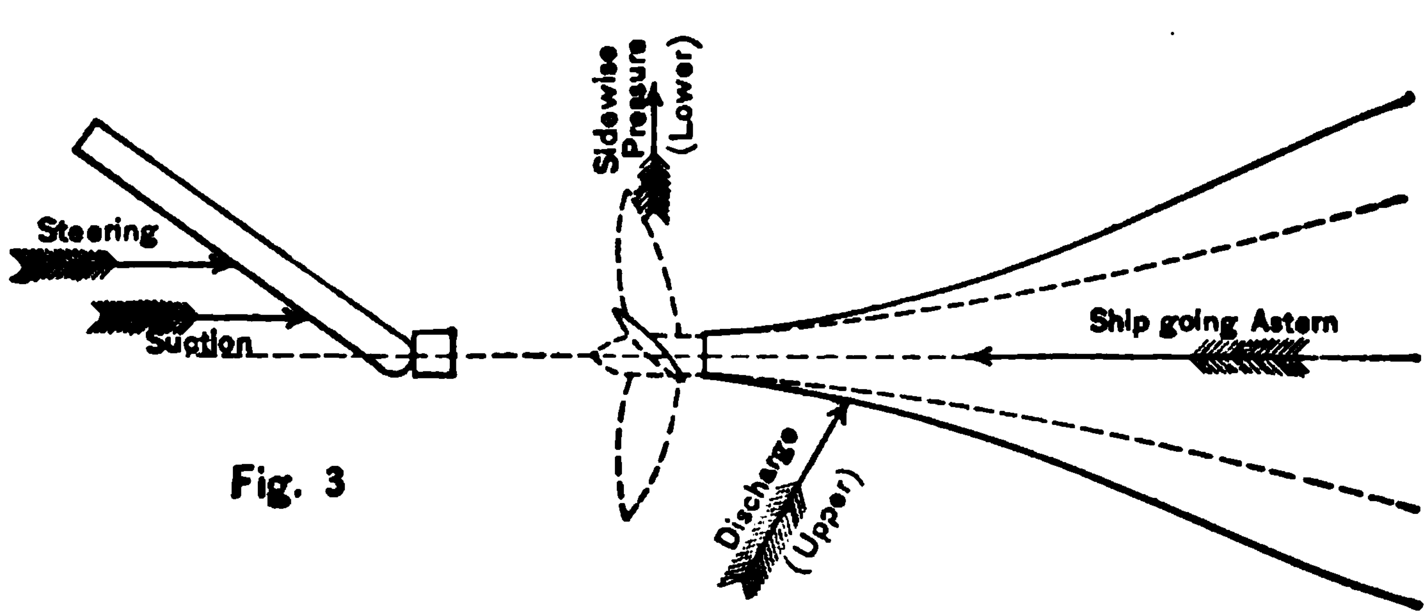
Fig. 2



Stern may go to Starboard, Head to Port.

Ship and Screw going Astern. Ship Moving Astern.

Fig. 3



Stern goes rapidly to Port, Head to Starboard.

EFFECTS OF SCREW UPON STEERING.

the stern toward the side to which the rudder is put. This factor does not enter into the problem with the rudder amidships.

3 and **4** above are closely related and act together, but **4** is dependent upon the motion of the ship through the water, while **3** is independent of this motion and connected only with the action of the screw. For this reason, we must distinguish between the case in which the ship is just starting astern from rest, and that in which she is moving astern with considerable velocity. In the first case we may ignore **4**, while in the other we must consider it. In both cases, we shall find an inclination for the stern to back to port, due to the fact that **1** and **2** always act in that direction, while **3** and **4** act with or against them according as the rudder is put to starboard or to port.

(a) If the ship is just beginning to back, **4** may be neglected, and **3** will tend to drive the stern to the side to which the rudder is put. If, then, the rudder is to the left, **3** will act with **1** and **2**, and the tendency to port will be very marked. If the rudder is to the right, **3** will oppose **1** and **2**, but will not usually overcome them; and the tendency of the stern to port though very much reduced, will still exist. In other words, a steamer just beginning to back from rest will in general throw her stern to port even against a hard-over right rudder.[1]

(b) As the ship gathers speed astern, 4, the steering effect of the rudder, becomes of greater and greater importance. It always acts with the suction current (3) upon the after side of the rudder; and if the rudder is put to right, these two forces (3 and 4) may ultimately overcome 1 and 2 and give the stern a slight tendency to starboard. If, on the other hand, the rudder is put to left, all four of the forces involved act together and throw the stern rapidly to port.

It results from the above, that when a ship with a single right-hand screw is beginning to back but has not yet gathered decided stern-board, it is difficult, if not impossible, to prevent her stern from working off to port; and that after she has gathered considerable speed astern, she will still have a decided inclination to back to port, but may usually be made to back to starboard by hard-over right rudder.

If it is desired to back as nearly straight as possible, the rudder must be put hard right.

[1] "Right rudder" is port helm.
"Left rudder" is starboard helm.

The effect of a breeze is not great upon a vessel moving slowly astern, but becomes important as the speed increases; so much so that, with a moderate breeze, a vessel going astern at a speed of three knots or more will back up into the wind in spite of all that can be done to prevent it. It follows that, in spite of the tendency to port which has been insisted upon above, a ship may be backed to starboard, if the breeze is from that side, provided that the circumstances admit of going astern for some time and at fair speed. It follows, also, that if it is desired to back to port while the breeze is from the starboard side, the more slowly we go astern the better, and if the breeze is fresh, it will probably be impossible to avoid backing into it.

Generally speaking, a ship is backed only when working alongside a dock or into a slip, or when manœuvring in crowded waters; conditions which do not admit of backing for a long time or at any considerable speed; and under these circumstances, it is desirable to plan all manœuvres in such a way as shall involve the throwing of the stern to port in backing.

SHIP GOING AHEAD. SCREW BACKING.

This is in some respects the most important case with which we have to deal, for the reason that it is the one most frequently connected with the emergency of danger suddenly discovered and close aboard. The cause of many collisions can be traced to a widespread ignorance of the rules which govern the steering when the engines are suddenly reversed while the ship is going ahead. Yet these rules are simple and have been stated many times.

It is assumed, naturally enough, by those who have not studied the many practical experiments which have been made in connection with this matter, that so long as the ship has headway she will continue to obey her helm in the usual way, even though the screw is backing and gradually reducing her speed.

This is so far from being the case, that in many instances exactly the opposite occurs; the matter being complicated, from the instant the engines are reversed, by the "screw current" which has been described in § I as being drawn in against the after side of the rudder and driven forward against the afterbody of the ship.

The forces involved in the steering under these conditions are the following:

1. The direct steering effect of the rudder, tending, as in all cases of headway, to throw the stern away from the side to which the rudder is put.

2. The "Suction" current, drawn in from aft by the screw, against the after side of the rudder, and forcing the stern toward the side to which the rudder is put.

3. The "Discharge" current driven forward and inward against the stern, forcing the stern to port, without reference to the rudder.

4. The Sidewise Pressure of the blades, also forcing the stern to port, without reference to the rudder.

(Plate 117.)

We have here a number of conflicting elements, the final result of whose action it would be useless to attempt to predict from theoretical considerations. Since, however, there are two of them which always act to throw the head to starboard, we may be sure, at least, that the ship will turn much more readily to that side than to the other.

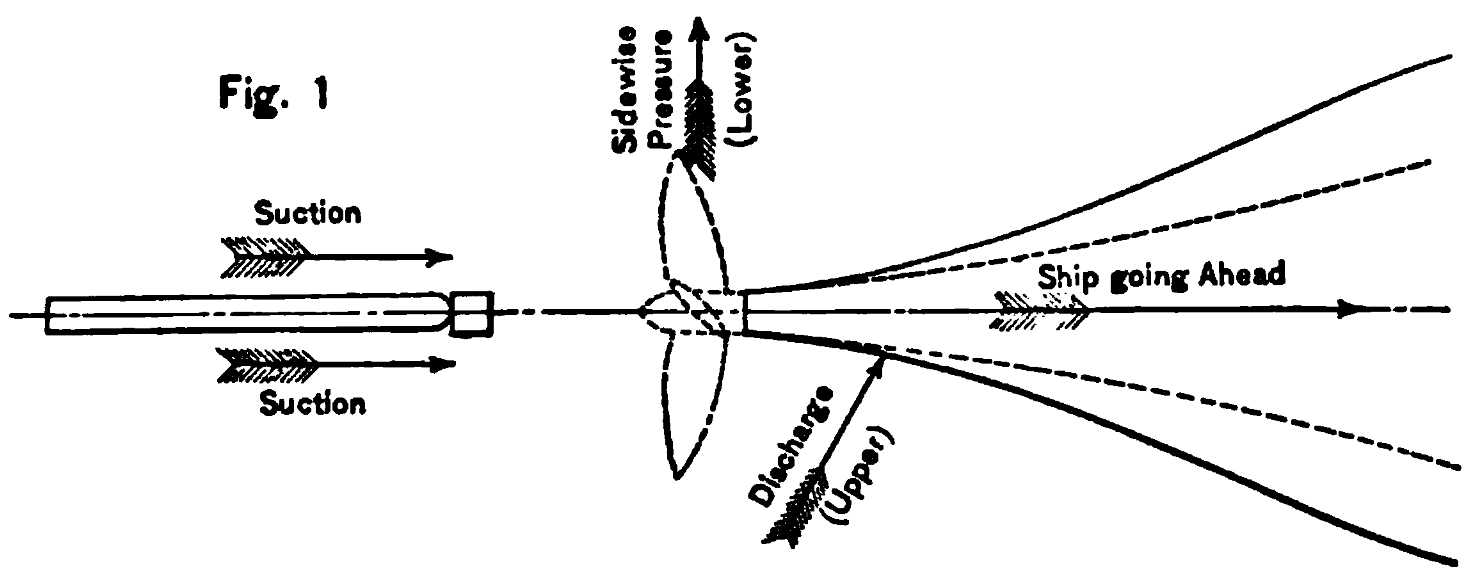
We proceed now to consider the matter from the point of view of practice, and we are fortunate in having the result of several very complete series of experiments, from which to draw our conclusions.

In 1875, Professor Osborne Reynolds communicated to the British Association for the Advancement of Science, the results of certain experiments made with models for the purpose of determining the effect of the screw upon the steering of steamers; and for several years after this time, he was engaged, as Secretary of a committee appointed by the Association, in experiments and investigations upon the same subject. The reports of this Committee are to be found in the Proceedings of the Association for 1876, 1877, and 1878.

Since these reports were made, much additional evidence has become available, and it is now possible to lay down fairly definite laws with regard to the behavior of ships under the circumstances we are now considering, although it must never be forgotten that exceptional conditions, especially of weather and of the draft and trim of a ship, may modify all such laws in ways which can only be foreseen by an officer thoroughly familiar with the peculiarities of his ship and her temporary condition as regards draft and trim.

Ship going Ahead. Screw Backing.

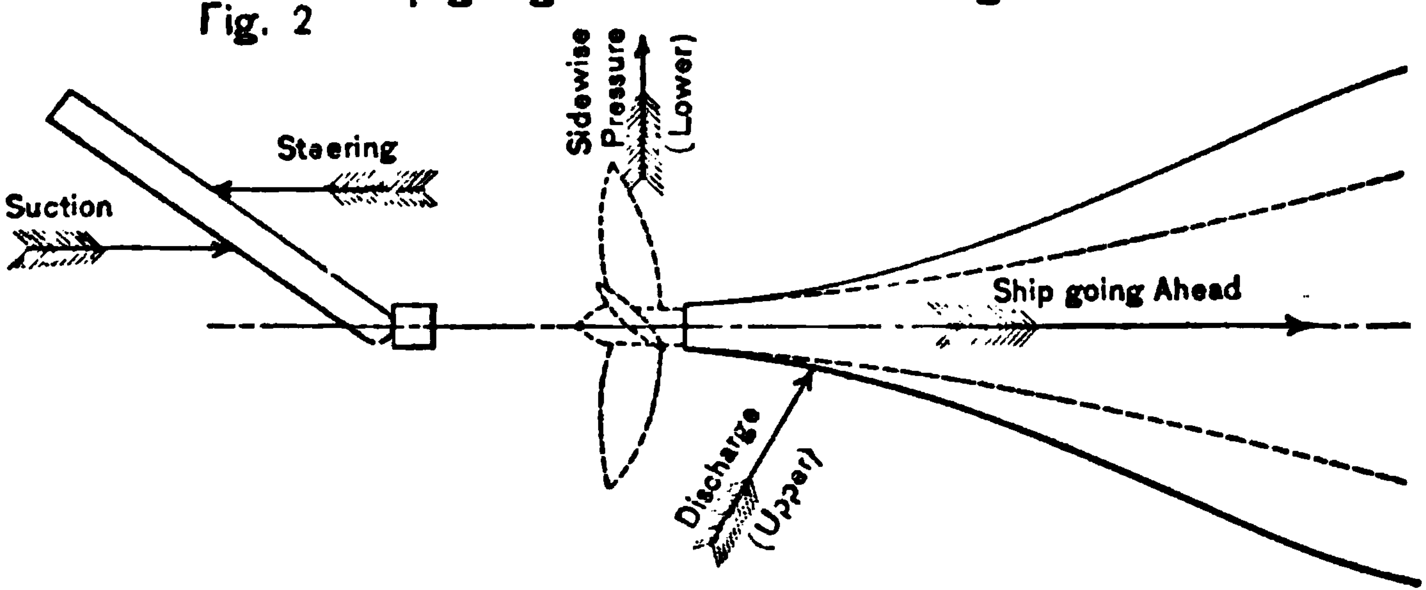
Fig. 1



Head goes to Starboard.

Ship going Ahead. Screw Backing.

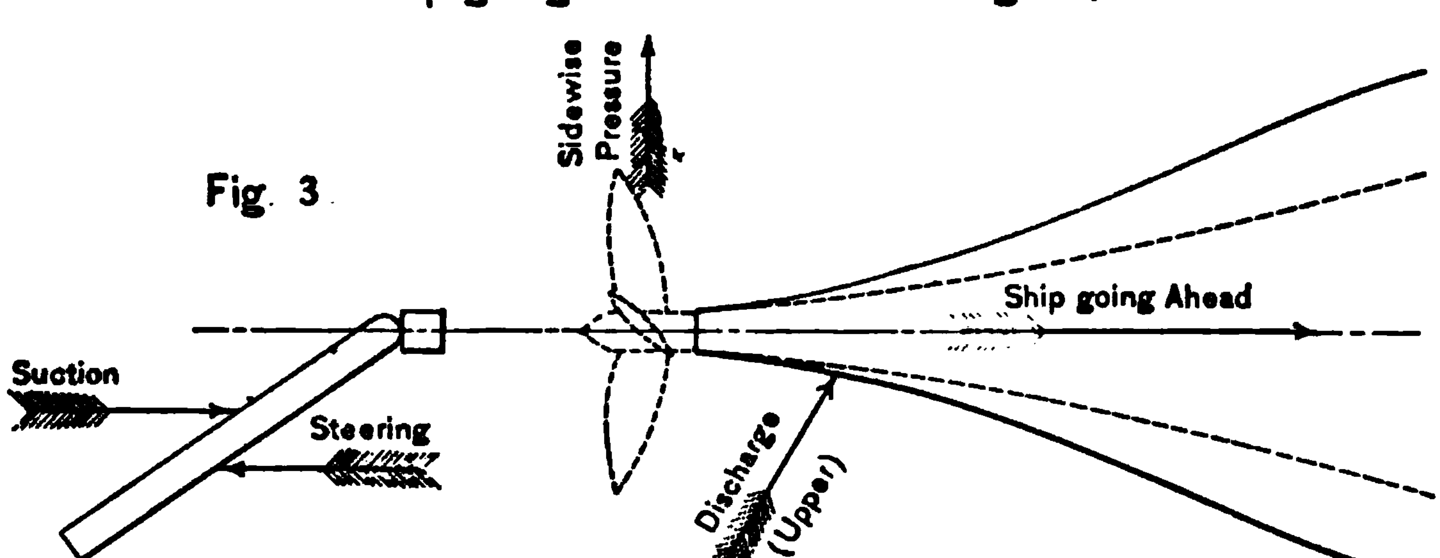
Fig. 2



Head goes to Starboard decidedly, May go slightly to Port at first.

Ship going Ahead. Screw Backing.

Fig. 3



Forces nearly balance. Head will usually go a little to Port.

EFFECTS OF SCREW UPON STEERING.

The following rules will usually be found to hold for our right-handed single screw steamer, of average characteristics, when the engines are suddenly reversed from full speed ahead to full speed astern.

(a) **The rudder kept amidships.**

The head will fall off to the starboard, and the ship will gain ground to the right before losing her way. The stern will, in the beginning, go off slightly to the left, and the mass of the ship will range along the line of the original course or a little to the left of it (Fig. 1, Plate 117).

(b) **The rudder put hard left at the same instant that the engines are reversed.**

The head will usually go to port at first, but neither very rapidly nor very far; it will then begin to swing to starboard and will fall off more or less to that side. The ship will gain ground to the right of her original course, before losing way (Fig. 2, Plate 117).

(c) **The rudder put hard right at the same instant that the engines are reversed.**

The head will at first go to starboard and may in some cases persist in swinging to that side, though not nearly so fast or so far as in (b). In a majority of cases, after swinging somewhat to starboard, it will stop and swing slowly back to port, and the ship will come to rest with her head from one to two points to port of her original course. She will not gain ground materially to either side (Fig. 3, Plate 117).

The more slowly the ship is moving ahead, and the faster the screw is backing, the more confidently may we expect her to behave as above described. The rules that have been given, and indeed the whole preceding analysis, suppose the screw to be backed at full speed from the first instant, as it should be in all cases where certainty of manœuvring is important.

If the ship is running slowly, but with a reserve of power immediately available for backing at high speed (as should always be the case in a fog), the rules which have been laid down may be relied upon with especial confidence, since they are based upon the power of the backing screw to overcome the steering effect of the rudder due to the speed of the ship. So in the other important case of turning or manœuvring in a limited space or working alongside a dock, where the power available for backing will always be great in proportion to the speed of the ship.

"Right rudder" is port helm. "Left rudder" is starboard helm.

If, on the other hand, while the ship is moving ahead at high speed, the engines should be reversed with only half power, the ship would unquestionably obey her rudder for headway; a right rudder throwing her head to starboard in spite of the slowly backing screw.

The case with which this section has chiefly dealt—that in which the screw is backed with power equal to or greater than that corresponding to the speed of the ship—is the ordinary case of practical seamanship, covering both the situation where the screw is backed for manœuvring a ship in harbor, and that where it is suddenly reversed when going ahead at some speed, to avoid danger suddenly discovered.

As the whole question herein dealt with is one of opposition between the steering effect of the rudder due to the speed of the ship and the steering effect due to the screw current, it will be easily understood that there may be cases in which the balance of these forces will be different from that which is here described for "average" conditions, and in which, accordingly, the behavior of the ship will differ from that described. But while we may admit that in some cases a ship backing her screw with full power will still obey her rudder for headway, it must be insisted none the less strongly that the screw current will have a powerful effect in the direction herein described and that if the ship obeys her rudder for headway it will be with greatly lessened effect.

The *time* of putting over the rudder exercises an important influence upon the behavior of the ship. If it is put over before reversing the engines, the ship's head will of course commence to swing in direct obedience to it (for headway), and the screw cannot be expected to overcome this and to produce the same effect as if it were reversed simultaneously with the putting over of the rudder.

If the ship has actually begun to swing in obedience to a hard-over rudder before the screw is reversed, she will in most cases continue to swing the same way in spite of the screw, although much less rapidly than if the screw were not reversed.

If, on the other hand, the engines are reversed before the rudder is put over, then the rules laid down above are emphasized; and it should be noted that the rudder can be put over more rapidly after the screw is reversed than before. This may be a very important point with ships steering by hand-power.

"Right rudder" is port helm. "Left rudder" is starboard helm.

It is probable as already intimated that some ships will, for a very short time, continue to obey the rudder as for headway, even though the rudder is put over at the same time that the screw is reversed; but as they will shortly begin to act in accordance with the above rules, there are very few cases in which we can run into any danger by considering the rules to hold.

We may usually remove all question with regard to the movement of the ship by putting the rudder to one side before reversing the screw, *thus getting a swing on the ship in the desired direction,* then reversing the screw, and following this up by reversing the rudder. Suppose, for example, we wish to throw the head to starboard. We stop the engines and put the rudder hard right, and when the head has begun to swing to starboard, reverse the engines and immediately shift the rudder to hard left. If we wish to turn to port, we stop, put the rudder to right, and wait a little longer than in the preceding case—(since the head does not turn to port as easily as to starboard with engines backing)—then throw the engines to full speed astern and follow this by putting the rudder hard right. By this means we shall remove all doubt about casting to port, although the turn to that side will be made slowly, even under these conditions.

The rules laid down above are summarized in the statement that, in general, a ship tends to obey her rudder with reference to the way the *screw* is moving, not with reference to the way the *ship* is moving.

SHIP GOING ASTERN. SCREW GOING AHEAD.

This case closely resembles the preceding one and is subject to the same general law: viz., the ship obeys her rudder with reference to the motion of the screw, not the motion of the ship.

The forces involved in the steering of a ship with a single right-hand screw are:

1. The direct Steering effect of the Rudder due to sternboard, acting to starboard or to port according to the way the rudder is put.

2. The Sidewise Pressure of the Blades, acting to drive the stern to starboard.

3. The Discharge Current thrown off by the screw, and con-

"Right rudder" is port helm. "Left rudder" is starboard helm.

sisting of two components; (a) acting directly astern, and (b) acting inward against the starboard side of the rudder post and tending always to force the stern to port.

If the rudder is amidships, 1 and 3 (a) are eliminated from the problem, and only 2 and 3 (b) are to be considered. These two oppose each other, and it is impossible to foresee, in any given case, which one will prevail (Fig. 1, Plate **118**).

If the rudder is to right, we shall have 1 and 2 forcing the stern to starboard, and opposed by both components of 3 (Fig. 2, Plate **118**).

It is found in practice that, under these conditions, the effect of 3 greatly exceeds that of the other factors, and that the stern goes off decidedly to port.

If the rudder is to left, we have 2 acting as before to force the stern to starboard, and assisted now by 3 (a), while 3 (b) acts with 1, to force it to port. In practice, the forces acting to starboard commonly prevail, and the stern goes to that side (Fig. 3, Plate **118**).

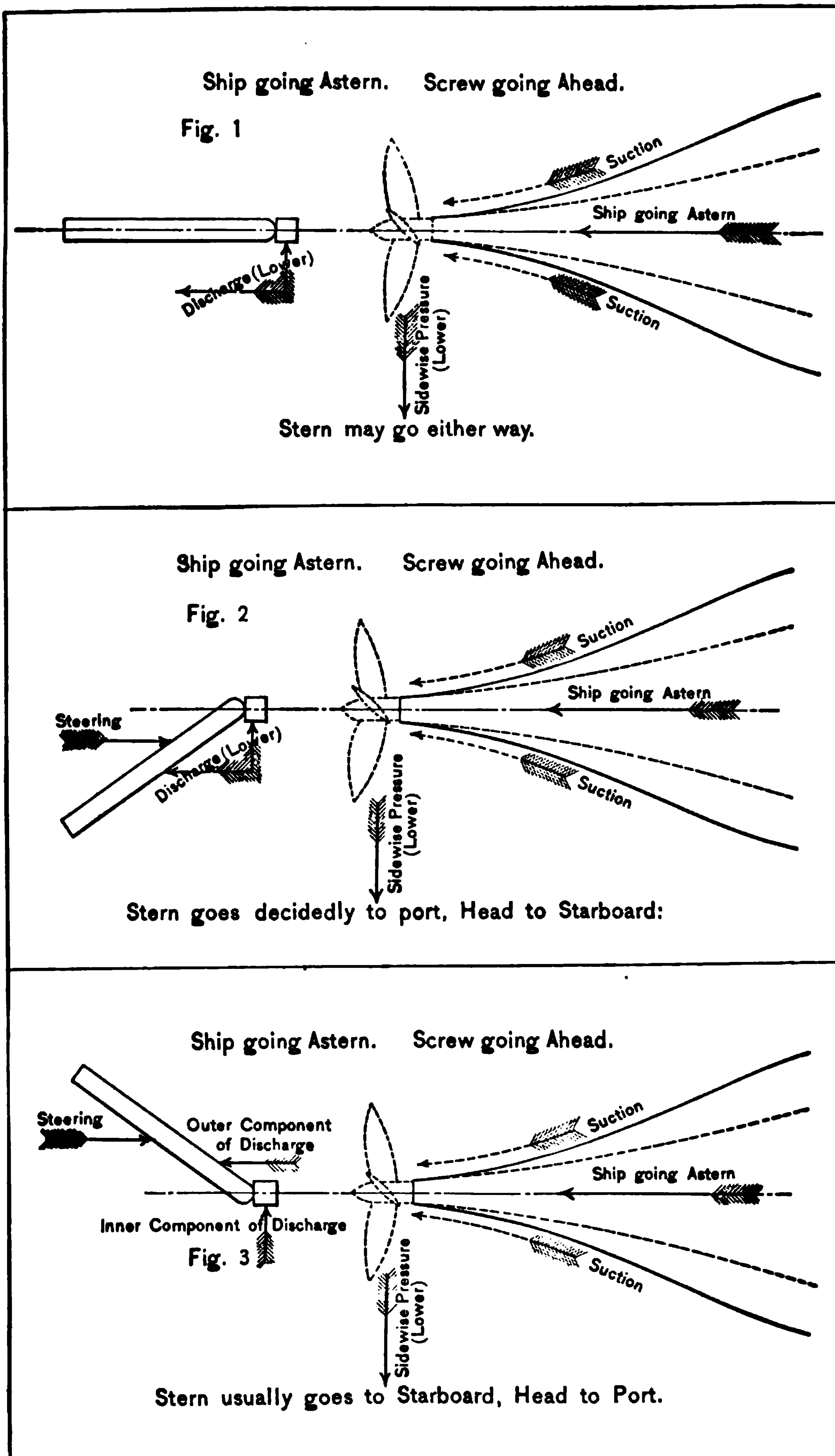
A comparison of the figures illustrating this case will show that 1 and 3 (a) are in every instance opposed to each other, as are also 2 and 3 (b). Of these forces, 1 and 3 (a) are by far the most important, and the course of the ship is usually determined by their relative values.

It is found in practice that, as a general rule, 3 (a) (the screw current acting against the forward side of the rudder), overpowers 1 (the resistance of the water on the after side), and, as already stated, the ship obeys her rudder with reference to the motion of the screw, not of the ship. This assumes that the sternward velocity of the ship is not great, and that the screw is turning ahead full speed—the usual conditions when manœuvring in this way. If the opposite conditions exist, that is to say, if the ship is moving rapidly astern and the engines are turning slowly ahead, it may be found that the natural steering power of the rudder will overcome the feeble screw current, and that the ship will obey her rudder as in ordinary cases of sternboard.

While the resemblance between this case and that of "Ship Going Ahead, Screw Backing" is very close, one important difference should be noted. The *discharge* current driven aft when the screw goes ahead is more directly localized in its effect

"Right rudder" is port helm. "Left rudder" is starboard helm.

Plate No. 118.



EFFECTS OF SCREW UPON STEERING

upon the rudder than is the *suction* current which is drawn in from aft by the screw when backing. While the suction current comes in a general way from abaft the screw and the rudder, only a part of it moves directly in line of the shaft, the remainder being sucked in from all sides more or less radially. The discharge current, on the other hand, although partaking to a certain extent of the radial motion of the blades, is localized upon the rudder as a distinct and powerful stream.

It results from this that the turning effect of the screw when the ship is going astern and the screw going ahead, is usually more pronounced than the corresponding effect when the ship is going ahead and the screw going astern.

TO TURN IN A LIMITED SPACE.

For reasons which have been already explained, it is difficult to turn a right-handed single screw steamer to port under any circumstances, where backing is necessary, and almost impossible to do so in a limited space. Under these conditions, therefore, the turn should, if possible, always be made to starboard, even if a little preliminary manœuvring is needed to place the ship in a position permitting this.

The ship being at rest, proceed as follows:

1st. Put the rudder to hard right and go ahead with the engines. The stern will swing off to port immediately. As she starts ahead, she will turn more and more rapidly. Allow her to gather as much way as is safe, and to forge ahead as far as space permits; then—

2nd. Reverse the engines full speed, and at the same time shift the rudder to hard left. The suction current against the after side of the rudder, assisted by the discharge current acting against the run, and by the pressure of the blades, will keep the stern swinging to port; and as she gathers sternboard (if allowed to do so), the direct steering action of the rudder will help in the same direction.

Let her gather such sternboard as is safe, and back as far as space permits; then—

3rd. Go full speed ahead and shift the rudder to hard right.

"Right rudder" is port helm. "Left rudder" is starboard helm.

It is at this point that the most pronounced turning effect is to be anticipated. The whole power of the screw is producing a screw current and driving this current against the hard-over rudder.

4th. If necessary, continue going ahead and backing as above (Plate **119**).

If more convenient to make a sternboard first, begin by backing with rudder hard left.

If there is a fresh breeze on the *starboard* hand, avoid gathering any considerable sternboard, or she will back into the wind in spite of all that can be done. If the breeze is on the *port* hand, there will be an advantage in going astern as fast and as far as the surrounding dangers permit.

If the space, although limited, is sufficient to admit of going ahead and astern for a considerable distance and at fair speed, it will not be so difficult to turn to port, although the turn to starboard will always be more easily and rapidly made. Having decided to turn to port under these circumstances, stand well over to the right-hand side of the channel, and go ahead with hard-over left rudder. Having got good way on her, stop the engines and let her run. So long as she holds her headway, she will turn without difficulty.

Having run as far over as is safe, back the engines at full speed and put the rudder hard right. As she is starting to back from rest, or nearly so, she will probably throw her stern the wrong way. Continue backing hard in spite of this, and as she gathers speed astern the right rudder will probably stop her turning the wrong way, and, if it does not turn her the right way, may at least hold her straight until you can afford to go ahead again. Then start the engines at full speed, put the rudder hard left, and, as before, run as far as space permits. If necessary, back again, and repeat the tactics as above.

If the tide is running out strong and setting you down toward danger, you should, in the early part of the turn, while heading more or less up stream, manage to gain ground against the tide while going ahead; and from the time when you have turned athwart and are beginning to throw the stern up stream, you should take on more sternboard (through the water) than you otherwise would, to hold her up against the current.

"Right rudder" is port helm. "Left rudder" is starboard helm.

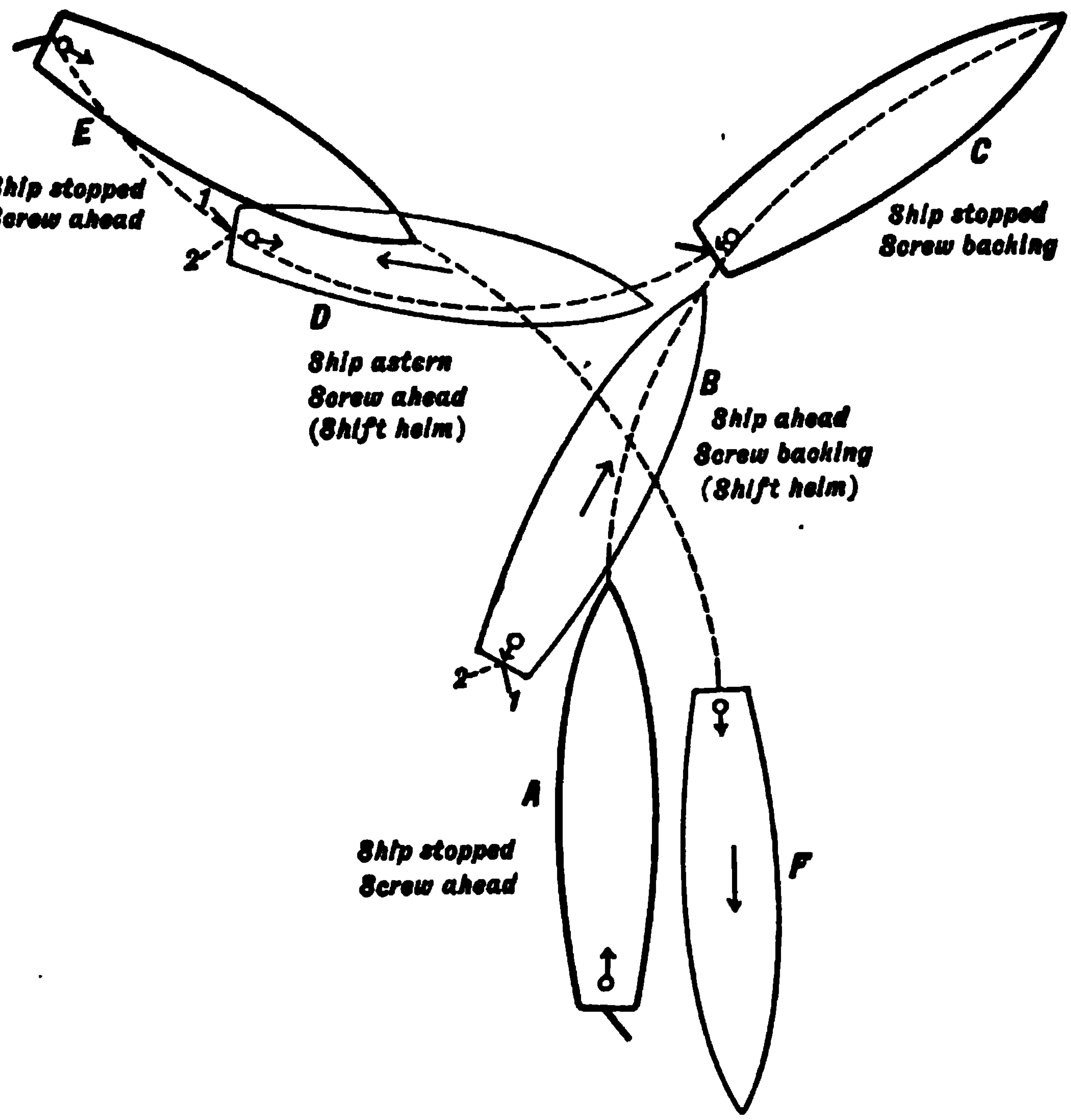


Fig. 1.

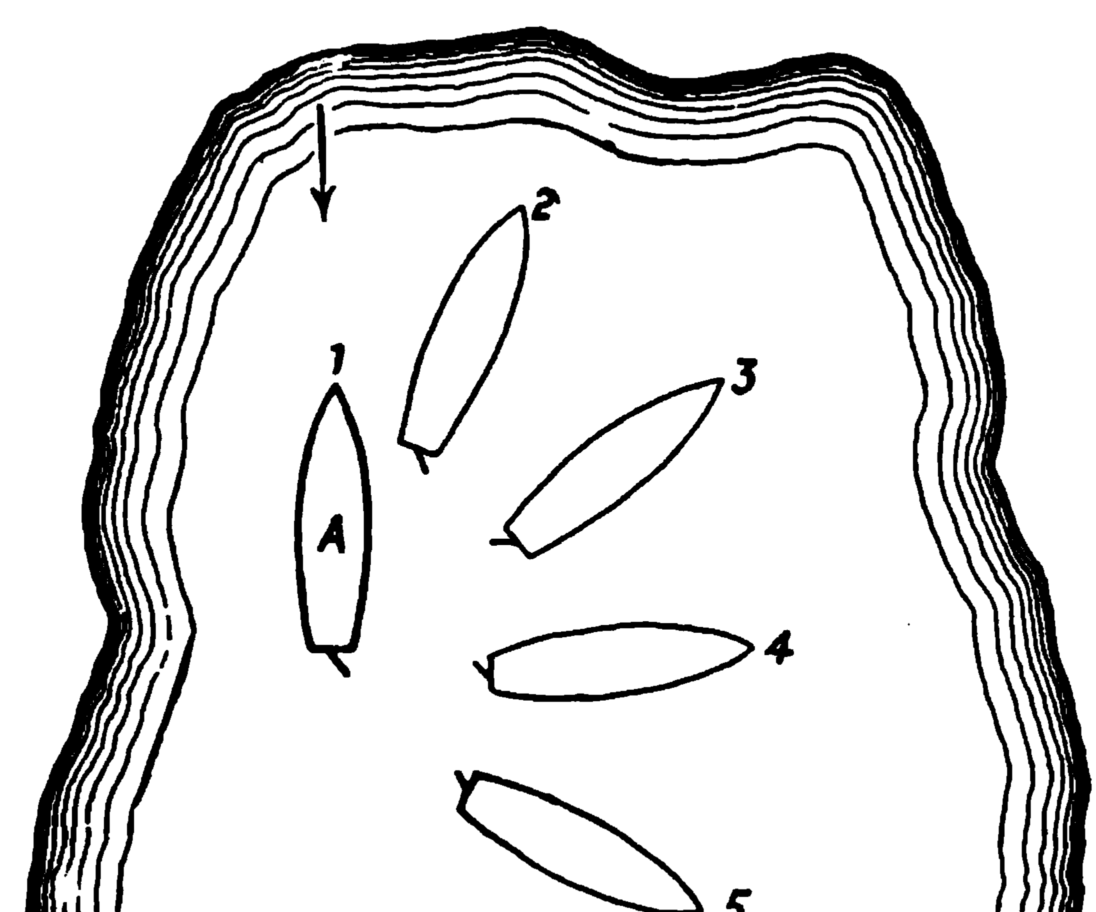


Fig. 2.

TURNING A STEAMER IN A LIMITED SPACE.
(SINGLE, RIGHT HANDED SCREW.)

A vessel drifting in a current and making no way through the water will usually fall athwart and end by drifting broadside on. This may be a serious danger. In going through Hell Gate, for example, a steamer should never be allowed to lose headway, as she will be beyond control if she gets athwart. On the other hand there are cases in which, with a little space for working ahead and astern, this tendency might be utilized to make a turn which, without it, would be impossible.

A similar but still more pronounced tendency to fall athwart exists where a vessel which is making no way through the water is subjected to a breeze. A vessel so placed will almost always fall off and bring the wind abaft the beam. Advantage may often be taken of this fact to turn a ship in a space in which turning would otherwise be almost impossible. In Fig. 2, Plate **119**, for example, *A*, wishing to get underway and stand out, weighs and cants his head a little to one side—preferably to starboard—if the screw is right-handed (Position 2). Then, with the engine stopped, he waits for the bow to fall off, under the influence of the wind, to Positions 3, 4, 5. At 5, the engines are backed and the stern swings up with the wind.

This manœuver is so simple, and applies to so many situations of turning in a limited space, that it is surprising how rarely it is used. It applies to twin-screw steamers as well as to those with single screw.

It often happens, where a current runs rapidly through a more or less narrow channel, that there is a perfectly marked eddy along the shore running in the opposite direction. This is the case in the East River, where, from the old Brooklyn Bridge to Corlear's Hook, an eddy current of considerable width runs up along the face of the New York docks while the ebb tide is running out with full force in mid-stream. A steamer coming down stream and having to turn to make a landing may run well over toward the Brooklyn side, then turn across with right rudder, ranging over and putting her bow in the eddy. In this way, she will turn with great ease. A similar phenomenon exists in the Mississippi at New Orleans, and ships may be turned there in the same way.

It is always worth while to post one's self upon such local peculiarities when likely to have occasion to deal with them.

"Right rudder" is port helm. "Left rudder" is starboard helm.

§ III. TWIN SCREWS.

Twin screws have been used for many years, but did not come into general use, either for men-of-war or for merchant steamers, until about 1870, since which date they have been steadily growing in favor. Their advantages are to a great extent connected with the smaller size of screws required for a given power—this reduction in size over that of a single screw permitting large power to be utilized on a small draft, and preventing the racing of the screw as the ship pitches in a seaway. Moreover, the division of power between two screws and two sets of engines permits the use of smaller parts in the machinery, and especially in the shafts. This reduces the danger of flaws and of breaking in these parts, and minimizes the disastrous consequences if such breakage occurs; since a twin-screw ship with one shaft broken or one engine disabled is still perfectly under control and loses only a moderate percentage of her speed.

On the other hand, there is a certain weakness, which becomes important in a modern steamship with a fine run, in the great length of shafting, which, with twin screws, must project outside the ship, supported by struts from the hull. There is also, no doubt, some danger of damage to the screws, which would not exist with a single screw, in entering and leaving docks.

The point in connection with twin screws with which seamanship is principally concerned, is the remarkable gain in manœuvring power which results from their use, and which is principally connected with the turning-leverage resulting from their position off of the midship line. It is clear that this must be very great in almost any case, though it will differ widely with different ships; being dependent, broadly speaking, upon the distance between the shafts at the center of gravity relatively to the length of the ship, and upon the angle at which the shafts are placed with each other.

In a ship of small beam as compared with her length, the shafts necessarily approach each other at a rather sharp angle; whereas with plenty of beam they can be kept nearly parallel and separated by a distance which gives a good turning moment.

In all cases where twin screws are used, one is right-handed and the other left-handed, the right-handed screw being placed to starboard and the left-handed screw to port, with the result

that in going ahead the upper blades of each screw turn *outward*.

There is an indirect, but very important gain in *certainty* of manœuvring power, where twin screws are used, resulting from the more or less complete elimination from the problem of the rather baffling steering effects of a single screw. We must still take account to some extent of the current which is driven aft by each screw in going ahead, and drawn from aft in backing; but the axes of these currents will be well clear of the keel-line and will not materially affect the steering unless the helm is hard over, or nearly so. In the case in which the ship is moving rapidly in one direction and the engines are suddenly thrown the other way, these currents will greatly reduce the steering power of the rudder, but will not *reverse* it, as in the case of a single-screw ship. Similarly, in turning with one screw going ahead and the other backing (the ship having headway) the suction current from the backing screw reduces the steering power of the rudder but does not entirely overcome it.

The steering effect due to the sidewise pressure of the blades, which, as we have seen, is often a very important factor in the handling of a single-screw ship, disappears with twin screws when both screws are going ahead or backing together. In other cases it may be very important, and the more so because it *acts with and is added to the turning effect arising from the leverage of the screws.* Suppose the port screw going ahead. The leverage due to its position on the port side of the center-line throws the ship's head to starboard. At the same time the sidewise pressure of the lower blades, which, as has been explained, greatly outweighs that of the upper blades, drags the stern to port, thus acting with the leverage of the screw to throw the head to starboard.

If, now, the starboard screw is backing, its leverage and the pressure of its lower blades also act to throw the stern to port, and the head to starboard. Moreover, the *discharge-current* from the upper blades of the backing screw is driven in against the starboard run and adds its effect to that of all the other forces which are acting to turn the ship to starboard.

It is evident then, that all the factors which have any real moment, *act together* toward turning the ship, in the one important case in which the attempt is made to turn by going ahead with one screw and backing with the other.

We proceed to consider the turning of twin-screw ships under various conditions:

We shall deal with the following cases:

1. Going Ahead.
2. Backing.
3. One screw going Ahead, the other Backing.
4. Ship going Ahead, both screws Backing.
5. Ship going Astern, both screws going Ahead.

1. Going Ahead.—So long as both screws are making the same speed, the ship should steer with helm amidships, unless affected by wind or sea.

If one screw is stopped, there should be no difficulty in steering a straight course with a moderate amount of helm.

If the steering gear is disabled, there should be no difficulty in making a reasonably good course, steering by the screws, unless the sea is heavy; but this supposes good and rapid communication between the bridge and the engines. In a seaway, there may be some difficulty about steering in this way, but not enough to prevent a ship from proceeding with perfect safety as long as she has sea-room; but we must, of course, recognize the fact that even under the most favorable conditions the screw can never give the sensitiveness of control that comes from a rudder governed by steam-power. *Experience shows that it is best to keep one engine turning over at a constant rate, somewhat less than the maximum available, and to steer the ship by varying the number of revolutions of the other screw.*

If the rudder be put hard over when going ahead at full speed, the result will be practically the same as in the case of a single screw. In fact, as already stated, the curves of Plate **113** have in some cases been derived from experiments upon twin-screw ships; and the discussions of these curves already given are entirely applicable to the case we are now considering. We have to recognize the same sweep of the stern to leeward, the same ranging ahead, along, and even to leeward of, the original course, before beginning to gain ground in the desired direction, and the same loss of speed while turning.

It is found that the revolutions of the inner screw are somewhat reduced in turning, the change amounting to perhaps 10 per cent.

From causes which cannot be clearly defined, and which are

probably different with different ships, it usually happens that a twin-screw ship turns somewhat more readily to one side than to the other; but the difference is less than with single screws, and is of practical importance only in the case where a full turn is to be made—as in the tactical manœuvring of men-of-war.

2. BACKING.—A twin-screw ship, starting from rest with both screws backing, should be entirely under the control of the rudder, though she will steer with much less ease and sensitiveness than when going ahead. If necessary, the rudder may be assisted by a variation in the speed of one or other of the two screws.

3. ONE SCREW GOING AHEAD, THE OTHER BACKING.—(a) If the ship is just starting from rest, with rudder amidships, she will turn rapidly to the side of the backing screw.

If the screws revolve at equal speed, the one going ahead will gain slightly upon the other, since less power is required to drive a ship ahead than to drive her astern, and the ship will turn in a circle of small radius, but not on her heel.

If it is desired to turn her as nearly as possible on her heel, the screw going ahead should be kept at somewhat lower speed than the other, the exact relation between the two being determined experimentally for each ship.

The time of turning under these conditions is considerably greater than where both screws are kept going ahead and the helm put hard over, although the space required is much less.

Many ships will not turn *from rest* by going ahead on one screw and backing on the other. With such a ship, it is necessary to gather a little way and commence turning by the rudder before backing the inner screw.

In the special case where the ship is to be turned without gathering headway, *the rudder should be kept amidships*. To make this clear, let it be assumed that the turn is to be made to starboard. The starboard screw will be backing and the port screw going ahead. To starboard of the rudder, then, we shall have a suction current moving forward, and, to port, a discharge current moving aft. If, now, we put the rudder hard right, the suction current will strike against the after side and tend to throw the head to port; while if we put the rudder to left, the discharge current will act against the forward side and will also tend to throw the head to port.

(b) If the ship is moving ahead at fair speed

when one screw is backed for the purpose of turning, the rudder should be put hard over as if the engines were both continued ahead. Wishing to turn to starboard, we put the rudder hard right, and reverse the starboard screw.

In this case, the suction current of the backing screw, acting upon the after side of the rudder, will oppose the turning, but not sufficiently to deprive the rudder of all steering power, as it often does in the case of a single screw. There are several reasons for the difference. In the first place, only half the power of the ship is involved in the backing, whereas with a single screw, the whole power is involved. Again, the suction current in the present case is at some distance to one side, and affects only the outer part of the hard-over rudder; and, finally, the headway is prolonged by the other screw, and this tends to continue the normal action of the rudder.

In turning, then, with considerable headway, and wishing to get the maximum effect, the rudder should be used as in ordinary turning, and the inner screw reversed.

As regards the track of the ship in turning under these conditions, we have seen that the curve of a twin-screw ship with both screws going ahead and rudder hard over, does not differ materially from that of a single-screw ship; but it would be natural to suppose that the case must be greatly changed when the inner screw is reversed to help the rudder. There is, in fact, a considerable difference, but it is far less than is commonly supposed; at least in the first brief interval after the turn begins; in the interval, that is to say, during which the emergency for which the action is taken must work itself out. The complete turning circles will be widely different, but the track of the vessel for some time will be but little modified. The stern will, as in all other cases, go off to leeward, and the ship will gain nothing to the side toward which her head is thrown, until she has covered from two to three lengths along her old track. She will, however, gradually lose her speed, and will throw her head around rather more sharply, with the result that, by the time she does begin to move away from her old line of advance, she will do so at a considerably greater angle than if her rudder were merely put over without reversing the inner screw.

"Right rudder" is port helm.
"Left rudder" is starboard helm.

4. Ship going Ahead, both Screws Backing.—In this case, if the rudder is kept amidships, the ship may be stopped in from three to five lengths, or double this for turbine ships.

If the rudder is put hard over to either side, we have a case resembling that in which the screw of a single-screw steamer is suddenly reversed; but with some points of difference. In the present case, we shall have a suction current on each side drawn forward by the screw of that side. Whichever way the rudder is put, its direct steering action for headway will be opposed by the suction current of that side alone; that is to say, by only half the power of the total suction. Moreover, this current is so far to one side that its effect will be confined to a small part of the area of the rudder.

Thus the twin screws, in backing, will have much less tendency than a single screw, to reverse the ordinary steering effect of the rudder; and it is found that so long as the headway continues, the ship steers normally (for headway), but turns less rapidly under the influence of the rudder than if the screws were going ahead; in other words, the screws in this case reduce, but do not reverse, the normal effect of the rudder.

There is an important gain in the rapidity of turning if the rudder is put hard over before the screws are reversed, thus starting the head to swinging in the right direction.

5. Ship going Astern, both Screws going Ahead.—In this case, the ship will obey her rudder for sternboard, although the power of the rudder will be materially reduced by the discharge current of the screws.

If necessary, the rudder may be helped, and the ship manœuvred with ease and certainty, by varying the speed of the screws.

§ IV. ADDITIONAL NOTES UPON STEERING.

EFFECT OF WIND.

If a steamer is lying in a smooth sea, with her engines stopped and with the wind abeam, she will gradually fall off and bring the wind abaft the beam; this for the reason that the draft is usually less forward than aft, so that the bow has less hold on the water than the stern; that, usually, the bow is higher than

the stern and so presents a greater surface to the wind; and that, above all, the screw acts as a drag holding the stern up to the wind.

In going ahead, the wind has no important effect. In backing, there is a marked tendency for the stern to back up into the wind. This tendency increases with the force of the wind and the speed of the ship, and differs greatly with different ships. Some ships cannot be backed at all, even in a light breeze, without throwing their sterns up to it, even though all other forces are acting to turn them the other way.

It will be clear from the above that advantage may be taken of the wind in manœuvring, and that its effect will be felt much more decidedly in backing than in going ahead. We shall have the maximum of favorable conditions for turning with a single screw, when the wind is fresh on the port hand. Under these conditions, everything favors turning to starboard; and it will be difficult, if not impossible, to turn to port.

The problem of handling a ship becomes one of especial difficulty when she is flying light. In this condition, she has less hold on the water and exposes more surface to the wind. Moreover, the effective rudder area is reduced, and the steering effect of the screw, due to incomplete immersion, is very greatly increased. Thus everything acts to minimize the control of the ship by the rudder. Under these conditions, a single-screw steamer may steer fairly well so long as she is in the open sea and under full speed, but she will handle very badly in a harbor, where she has no opportunity to get up speed; and if the breeze is fresh she will be nearly or quite unmanageable. The effect of the screw is to throw her stern off to the side from which the lower blades are moving; so that the bow falls off to port in going ahead, and to starboard in backing. If the wind and screw act together in any given case, the rudder will be practically useless if acting against them; if they oppose each other, it may have some power to control the ship, but the power will, at best, be far below what it is in ordinary conditions of trim. The conditions above described are much less important to a twin-screw ship than to one with a single screw, but they must still be recognized and allowed for.

It can hardly be necessary to state that the ship when flying light will drift bodily to leeward much more rapidly than under

ordinary conditions; and that the tide is of relatively greater importance than usual, because of the comparative helplessness of the ship.

EFFECT OF SEA.

A ship lying at rest in a seaway will gradually fall off into the trough of it, and some effort will be required to hold her up. If going ahead, she will tend to keep in the trough, and lee helm will be needed to bring her head to it; but if the engines are backed, she will throw her stern up to the sea exactly as she would to the wind, and this in spite of all that can be done to prevent it.

The longer the ship, the more decided will be the tendency to lie in the trough of the sea.

There may be special features of design or of the trim which will materially affect the steering of the ship. If she trims by the head, she may, when lying at rest with a beam wind, gradually throw her head up to it instead of her stern, although the chances are that the drag of the screw will prevent this.

If her after deadwood is cut away somewhat more than in ordinary designs, her hold upon the water will be reduced and there may be difficulty in holding her to a straight course. On the other hand, she will be very sensitive to small changes of rudder, and will turn in small space, her stern being thrown off to leeward very decidedly by hard-over rudder.

EFFECT OF SHALLOW WATER.—It is well known that ships do not manœuvre as well in shallow as in deep water, and it not infrequently happens that a vessel which steers perfectly in the open sea becomes very wild in channels where she has only a few feet of water under her keel. The explanation lies in the fact that the displaced water cannot flow off freely along the natural wave lines due to the shape of the under-water body. For similar reasons, the *speed* is reduced in shallow water as compared with that due to the same power in water deep enough to allow a free flow of the displaced water.

* * * * * * *

The preceding sections, as carefully explained in the beginning, relate to ships of average characteristics in all respects. They illustrate principles which are broadly true of all ships, but which

must be modified in one direction or another if we seek to apply them to ships of exceptional build, speed, trim or manœuvring power. This is illustrated in the **turning curve** of the Yashima, already referred to. The facts that her after deadwood is cut away much more than is usual, that her rudder is exceptionally large, and that her steering-gear admits of putting the helm over very quickly, result in an excessive "kick;" and this, coupled with the momentum due to high speed, results in the peculiarities which have been noted in her turning circle. If, in addition to the features just detailed, she were of light draft and flat bottom, certain of her peculiarities would be exaggerated still further, the conditions in such a case approximating to those involved in certain types of speed boats which have very high speed and extraordinary turning power associated with light draft and a floor comparatively flat. Such a boat, upon putting her helm hard over at full speed, turns sharply, but may drive along her original line even after she has turned her broadside nearly full towards it. In the manœuvring of such a craft as this, there is brought out strikingly another point which to a greater or less degree appears in all cases of turning. This is the outward heel of the ship, due to the momentum and the centrifugal force acting outward from the center, and to the lateral resistance of the water, which acts inward, but usually below the center of gravity, so that it adds to outward heel. These heeling forces are to some extent offset by the lateral water pressure on the rudder, which, acting on the inside, and below the center of gravity, has a tendency to produce inward heel. The heeling of large ships in turning is rarely of practical importance; but in small craft it may be a source of considerable danger. Suppose such a boat, whose build happens to be favorable for heeling, to be turning at full speed and with hard-over helm while at the same time rolling more or less in a seaway. The hard-over helm acts, as already noted, to counteract the other forces and reduce the outward heel. If, now, the helm is suddenly eased, this counteracting force is removed, and the boat lurches sharply outward; and if it happens that she is at the same instant rolled outward by an impulse from a wave, she may be unable to recover and may capsize.

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The forces thus far described as involved in the turning of a

ship are all more or less under the control of those who must manœuvre her; or, if not under control, must be understood in order that she may be handled intelligently. They are thus properly matters of *Seamanship*. It will be interesting now to glance at a few points of a slightly different kind.

As the helm is put over, the ship begins to turn, or to acquire angular velocity, and for our present purpose we may consider the turning as taking place about the center of gravity of the ship. The turning is opposed by the resistance of the water to lateral displacement of the bow and stern; but as, in the beginning, this resistance is small—the turning being slow—the velocity of turning rapidly increases. This increase results in a still more rapid increase of resistance, and presently the two sets of forces, those producing and those opposing, the angular velocity, balance each other, and this velocity becomes constant. From this time on, the ship turns in a curve which is practically a circle, her bow maintaining a steady angle, technically known as the "drift angle," to the tangent of the circle.

An important point in connection with the turning of a ship has to do with what is known in mechanics as the "moment of inertia," of which we need only explain here that it depends upon the distribution of weights in the ship with reference to the center of gravity. The significance of this point may be made clear by a simple illustration. Suppose we have a long rod pivoted at its middle point (the center of gravity) and carrying on each side of the pivot a weight which may be moved in and out. If the weights are kept close in to the pivot, the rod will be easily turned and stopped; whereas if the weights are run out to the ends, a much greater effort will be required to start it, and, after it is started, to stop it. In the first case, the moment of inertia is small and the rod is easily controlled; in the second, the moment of inertia is large, and considerable force is required to control it. Similarly, ships with their weights near the ends have large moments of inertia and are more difficult to manœuvre than those whose weights are concentrated more nearly amidships, and whose moments of inertia are accordingly small.

It is important that all officers should be familiar with the manœuvring peculiarities of the ships which they are called upon

to handle, and every effort should be made to determine and record these peculiarities at the very beginning of her service, a "ship's book" being kept, in which the results of all experiences are carefully entered. This book should contain the following information:

1. The turning circles of the ship, with right and left rudder,* —and with different degrees of rudder carefully plotted to scale and showing the "kick," the "drift angle," the "tactical diameter," the "advance," the "transfer," etc.

2. The time and distance required to bring the ship to rest by backing with full power at several different speeds.

3. The behavior of the ship in stopping under the conditions of 2; whether the head goes to starboard or to port and how far.

4. The result of putting the helm over either way during the manœuvre of 2.

5. The effect upon this manœuvre of using a reserve of power for backing.

6. The effect upon this manœuvre of varying the time at which the helm is put over; before reversing the engines, after reversing, simultaneously with reversing.

7. The effect of wind in backing.

8. The best way to work helm and engines for turning in a limited space, and the shortest space in which the ship can be turned

The methods of obtaining these data, as prescribed for ships of the United States Navy, are given in the Appendix. As usually carried out, often hurriedly and with conditions far from ideal, they leave much to desire in accuracy of results.

* "Right rudder" is port helm. "Left rudder" is starboard helm.

CHAPTER XIV.

THE RULES OF THE ROAD.

§ I. REGULATIONS FOR PREVENTING COLLISION.

The Regulations for Preventing Collision include:

1. **The International Rules,** established by agreement between maritime nations as governing navigation on the high seas.

   Article 30 of the International Rules, reads as follows:

   "Nothing in these Rules shall interfere with the operation of a special rule duly made by local authority, relative to the navigation of any harbor, river, or inland waters."

2. **The Inland Rules** enacted by Congress and governing the navigation of the inland waters of the United States.

3. **The Pilot Rules** for United States Inland Waters, supplementing the Inland Rules.

   These Rules are established by the Board of Supervising Inspectors of Steam Vessels, and are published in a pamphlet entitled "Pilot Rules for Atlantic and Pacific Coast Inland Waters."

4. **Local Regulations** for the navigation of various harbors, rivers, etc., of countries other than the United States.

   These rules are numerous and in some cases important, but they must in general be obtained from pilots or other local authorities.

Important decisions by the courts in connection with the Rules of the Road can be found in the "Federal Reporter Digest," which gives a brief digest of all important decisions under "Collision "with sub-heads, such as "Speed in a Fog," "Lights," etc.

Other valuable works on the subject are: **Collisions at Sea,** by R. G. Marsden; **Collision at Sea,** by Julian B. Swope; **Rules of the Road at Sea,** by H. Stuart Moore; **A Treatise on the Law of Marine Collisions,** by Herbert R. Spencer; and **Rules of the Road at Sea,** by W. H. LaBoyteaux.

The INTERNATIONAL RULES and the INLAND RULES are printed in parallel columns facing each other on the following pages of this chapter. Where there are important differences between the two sets of Rules, attention is called to the difference by the use of special type.

The PILOT RULES are embodied in the INLAND RULES at the points where they belong. They are, in fact, a part of the INLAND RULES, since they derive their authority from a clause of the law of Congress by which the INLAND RULES were enacted.

§ II. INTERNATIONAL RULES.

Preliminary Definitions.

In the following rules every steam-vessel which is under sail and not under steam is to be considered a sailing-vessel, and every vessel under steam, whether under sail or not, is to be considered a steam-vessel.

The word "**steam-vessel**" shall include any vessel propelled by machinery.

A vessel is "**under way**" within the meaning of these rules when she is not at anchor, or made fast to the shore, or aground.

II.—LIGHTS, AND SO FORTH.

The word "**visible**" in these rules when applied to lights shall mean visible on a dark night with a clear atmosphere.

Article 1. The rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such time no other lights which may be mistaken for the prescribed lights shall be exhibited.

Steam-vessels—Masthead Light.

Art. 2. A steam-vessel when under way shall carry—(a) On or in front of the foremast, or if a vessel without a foremast, then in the forepart of the vessel, at a height above the hull of not less than twenty feet, and if the breadth of the vessel exceeds twenty feet, then at a height above the hull not less than such breadth, so, however, that the light need not be carried at a greater height above the hull than forty feet, *a bright white light,* so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, namely, from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least *five miles.*

Steam-vessels—Side-lights.

(b) On the starboard side a *green light* so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead

§ II. RULES FOR UNITED STATES INLAND WATERS.

Preliminary Definitions.

In the following rules every steam-vessel which is under sail and not under steam is to be considered a sailing-vessel, and every vessel under steam, whether under sail or not, is to be considered a steam-vessel.

The word "steam-vessel" shall include any vessel propelled by machinery.

A vessel is "**under way**," within the meaning of these rules, when she is not at anchor, or made fast to the shore, or aground.

II.—LIGHTS, AND SO FORTH.

The word "visible" in these rules, when applied to lights, shall mean visible on a dark night with a clear atmosphere.

Art. 1. The rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such time no other lights which may be mistaken for the prescribed lights shall be exhibited.

Steam-Vessels—Masthead Light.

Art. 2. **A steam-vessel** when under way shall carry—(a) *On or in front of the foremast,* or, if a vessel without a foremast, then in the forepart of the vessel, *a bright white light* so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, namely, from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least five miles.

Steam-Vessels—Side-Lights.

(b) *On the starboard side a green light* so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead

to two points abaft the beam on the starboard side, and of such a character as to be visible at a distance of at least two miles.

(c) On the port side a *red light* so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side, and of such a character as to be visible at a distance of at least two miles.

(d) The said green and red side-lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.[1]

NOTE 1.—A very little consideration will show that these lights can not be prevented from showing to some extent across the bow. The flame of the lamp must have a certain width, and the lamp as a whole must stand out at some distance from the inboard screen. In addition to this, there will always be a reflection, visible at a certain distance, from the outer (after) side of the light box. The mere use of a screen projecting three feet forward can do very little toward correcting this. The matter is a serious one, involving danger which is the greater because seldom realized. If we see all the lights of a steamer, we assume, and the law justifies us in assuming (see Art. 18), that she is heading directly toward us. But if her lights show a point across the bow, we may misjudge her course by a point; and if she makes a corresponding error with regard to our lights and our course, the situation may be one of grave danger.

Although this difficulty can not be entirely done away with, it can be much reduced, by a batten of wood placed vertically along the forward edge of the fore and aft screen, and projecting out-board so that its outer edge shall be tangent to a line drawn through the inner edge of the wick, parallel to the keel line.

A light so screened will still show nearly or quite half a point across the bow, depending upon the width of the wick. This width is fixed by an English rule at "not less than one inch, nor more than two inches." A two-inch wick screened as above will show nearly 4° across the bow.

In inspecting the lights and their fittings, it is important to see that the after screen complies with the requirement that the light shall show only 2 points abaft the beam.

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Steam-vessels—Range-lights.

(e) A steam-vessel when under way *may* carry *an additional white light* similar in construction to the light mentioned in subdivision (a). These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.[3]

NOTE 2.—The range-lights, as herein described, while giving far less information than they might be made to give if their position were more definitely fixed by law, are nevertheless so useful that it is to be hoped they may, before many years, be made compulsory for all steamers at all times when under way. They are at present compulsory within the interior waters of the United States for all other than "sea-going" steamers and ferry-boats. (See "Inland Rules" for United States. Art. 2. f.)

It is clear that, supposing a vessel carrying such lights to be seen on an even keel, the lights will show one above the other when she is heading toward the observer; that if she changes course, the lights will open out, the lower one (which is also the forward one), drawing away from the upper one, in the direction to which the ship's head is changing. If the position of the lights were definitely fixed by law, the angle of the line joining them would be an indication of the course steered; but since neither the vertical nor the horizontal distance between them is established, they can not usually be regarded as giving much more information about the course than is given by side-lights. They have, however, one very great advantage over side-lights, in that, after being once clearly sighted, a change in their relative position gives instant notice of a change of course. This indication is especially sensitive when the vessel carrying the light is heading toward the observer, or nearly toward him, and this happens to be the point where the signals given by side-lights are often dangerously misleading. (See note 1.)

There is, of course, the farther very great advantage in range-lights over side-lights, that they can be seen at a much greater distance and thus give earlier notice as to the approximate course of the steamer carrying them. Their value would be considerably increased if we could be sure of finding associated with them the permanent white stern light *permitted* by the second part of Art. 10; but as the law stands, these two "permissive" clauses have no connection with each other, and we are not justified in assuming that a steamer which carries range-lights will also carry a permanent stern light.

It should be noted that when the vessel carrying range-lights is seen end-on, these lights may be confused with the lights of a vessel towing.

Steam-vessels—Range-lights.

-going steam-vessel when under way may carry an *hite light,* similar in construction to the light men- ıdivision (a). These two lights shall be so placed in keel that one shall be at least fifteen feet higher than d in such a position with reference to each other that ;ht shall be forward of the upper one. The vertical ween these lights shall be less than the horizontal

;team-vessels (except sea-going ves- ferry-boats) shall carry in addition and red lights required by article two and screens as required by article two ntral range of two white lights, the ht being carried at an elevation at een feet above the light at the head of el. The head-light shall be so con- as to show an unbroken light through oints of the compass, namely, from ead to two points abaft the beam on de of the vessel, and the after-light how all around the horizon.

Steam-vessels—When Towing.

Art. 3. A steam-vessel when **towing** another vessel shall, in addition to her side-lights, carry *two bright white lights* in a vertical line one over the other, not less than six feet apart,[3] and when towing **more than one vessel** shall carry *an additional bright white light* six feet above or below such light, if the length of the tow, measuring from the stern of the towing vessel to the stern of the last vessel towed, exceeds six hundred feet. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in article two[4] (a), excepting the additional light, which may be carried at a height of not less than fourteen feet above the hull.[5]

Such steam-vessels may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

NOTE 3.—These lights may be confused with the range-lights of a steamer seen end-on. Moreover, the range-lights and towing-lights may be carried by the same vessel, which may thus, when seen end-on, show as many as four lights in a vertical line.

NOTE 4.—Under Art. 9 (b), fishing-vessels off the European coast north of Cape Finisterre, carry, when fishing with drift-nets, two white lights, which may be confused with those of vessels towing. This calls for caution. A steamer in the neighborhood of a fishing ground, and having, perhaps, passed a number of fishing boats showing these lights, might easily fail to recognize a steamer towing, if she should chance to meet one.

NOTE 5.—That is to say, if two lights are carried, the lower one shall comply, as to height, with the requirements of Art. 2, for the regular masthead light; and if three are carried, the middle one shall comply with these requirements.

It is found that two lights separated by six feet blend into a single light at distances beyond about four miles.

Special Lights.

Art. 4. (a) A vessel which from any accident is **not under command** shall carry at the same height as the white light mentioned in article two (a), where they can best be seen, and if a steam-vessel in lieu of that light, *two red lights,* in a vertical line one over the other, not less than six feet apart, and of such a character as to be visible all around the horizon at a distance of at least

Steam-vessels—When Towing.

Art. 3. A steam-vessel when **towing** another vessel shall, in addition to her side-lights, carry *two bright white lights* in a vertical line, one over the other, not less than three feet apart, and when towing more than one vessel, shall carry an additional bright white light three feet above or below such lights, if the length of the tow, measuring from the stern of the towing vessel to the stern of the last vessel towed, exceeds six hundred feet. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in article two (a) or the after range-light mentioned in article two (f).

Such steam-vessel may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

Art. 4 of the International Rules is omitted from the Inland Rules. In inland waters, therefore, a vessel not under command and a vessel laying or picking up a telegraph cable, carry the same lights as other vessels.

Plate No. 121.

STEAMER TOWING WITHOUT RANGE LIGHTS.

two miles; and shall by day carry in a vertical line one over the other, not less than six feet apart, where they can best be seen, *two black balls or shapes*, each two feet in diameter.

(b) A vessel employed in laying or in picking up a **telegraph cable** shall carry in the same position as the white light mentioned in article two (a), and if a steam-vessel, in lieu of that light, *three lights* in a vertical line, one over the other, not less than six feet apart. The highest and lowest of these lights shall be *red*, and the middle light shall be *white*, and they shall be of such a character as to be visible all around the horizon at a distance of at least two miles.[6] By day she shall carry in a vertical line, one over the other, not less than six feet apart, where they can best be seen, *three shapes* not less than two feet in diameter, of which the highest and lowest shall be globular in shape and *red* in color, and the middle one diamond in shape and *white*.

NOTE 6.—The middle one of these lights, being white, will usually be seen before the others, and may be mistaken, until the other lights are seen, for a steamer's masthead light.

(c) The vessels referred to in this article, when not making way through the water, shall not carry the side-lights, but when making way shall carry them.

(d) The lights and shapes required to be shown by this article are to be taken by other vessels as signals that the vessel showing them is **not under command** and can not therefore get out of the way.

These signals are not signals of vessels in distress and requiring assistance. Such signals are contained in article thirty-one.

Lights for Sailing-vessels and Vessels in Tow.

Art. 5: A sailing-vessel under way and any vessel being towed shall carry the same lights as are prescribed by article tw steam-vessel under way, with the exception of the whit mentioned therein, which they shall never carry.

Lights for Sailing-Vessels and Vessels in Tow.

Art. 5. **A sailing-vessel under way or being towed** shall carry the same lights as are prescribed by article two for a steam-vessel under way, with the exception of the white lights mentioned therein, which they shall never carry.

NOTE 7.—No lights are prescribed for steam-vessels being towed in inland waters. Such vessels, however, carry the same lights as sailing-vessels being towed.

NOTE 8.—The following lights are carried by barges and canal-boats in tow: "In the Hudson River, the East River and Long Island Sound, to and including Narragansett Bay, barges and canal-boats carry white lights at bow and stern. The last vessel of the tow carries two white lights at the stern, placed athwartship. Where a number of them are massed in one or more tiers, the limits of the tow are marked by white lights carried at the bow of the outside boats and an additional white light at the stern of each of the two outside boats of the last tier."

In waters other than those above-named, barges and canal-boats in tow carry colored side-lights; and where they are massed in tiers, these lights are carried at the bows of the outside barges of each tier.

Ferry-boats carry the side-lights and range-lights of other steamers except that double-ended ferry-boats carry a *central range of white lights* showing all around the horizon and placed *at equal heights* forward and aft; in place of the range-lights of other vessels.

In addition to the above, ferry-boats may carry a special light, white or colored, on a flag-staff amidships, 15 feet above the white range-lights for the purpose of distinguishing different lines of ferry-boats from each other.

Lights for Small Vessels.

Art. 6. Whenever, as in the case of small vessels under way during bad weather, the green and red side-lights can not be fixed, these lights shall be kept at hand, lighted and ready for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side, nor the red light on the starboard side, nor, if practicable, more than two points abaft the beam on their respective sides. To make the use of these portable lights more certain and easy the lanterns containing them shall each be painted outside with the color of the light they respectively contain, and shall be provided with proper screens.

Lights for Small Steam- and Sail-Vessels and Open Boats.

Art. 7. Steam-vessels of less than forty, and vessels under oars or sails of less than twenty tons gross tonnage, respectively, and rowing boats, when under way, shall not be required to carry the lights mentioned in article two (a), (b), and (c), but if they do not carry them they shall be provided with the following lights:

First. **Steam-vessels of less than forty tons** shall carry—

(a) In the forepart of the vessel, or on or in front of the funnel, where it can best be seen, and at a height above the gunwale of not less than nine feet, a bright white light constructed and fixed as prescribed in article two (a), and of such a character as to be visible at a distance of at least two miles.

(b) Green and red side-lights constructed and fixed as prescribed in article two (b) and (c), and of such a character as to be visible at a distance of at least one mile, or a combined lantern showing a green light and a red light from right ahead to two points abaft the beam on their respective sides. Such lanterns shall be carried not less than three feet below the white light.

Second. **Small steamboats,** such as are carried by sea-going vessels, may carry the white light at a less height than nine feet above the gunwale, but it shall be carried above the combined lantern mentioned in subdivision one (b).

Lights for Small Vessels.

Art. 6. Whenever, as in the case of vessels of less than ten gross tons under way during bad weather, the green and red side-lights can not be fixed, these lights shall be kept at hand, lighted and ready for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side nor the red light on the starboard side, nor, if practicable, more than two points abaft the beam on their respective sides. To make the use of these portable lights more certain and easy the lanterns containing them shall each be painted outside with the color of the the light they respectively contain, and shall be provided with proper screens.

Lights for Open Boats.

Art. 7. **Rowing boats,** whether under oars or sail, shall have ready at hand a lantern showing a white light which shall be temporarily exhibited in sufficient time to prevent collision.

STEAM PILOT VESSEL UNDER WAY.

At Anchor.

Under Way.
(Shows Flare-up at Intervals,)

At A
(Shows Flare-up at Intervals)

STEAM PILOT VESSEL.

Making Way thro' Water

VESSEL NOT UNDER COMMAND

VESSELS LIGHTS.

Steam Trawler.

Line Fishing.

Drift Net Fishing.

Sailing Trawler or Dredge.

Any Fishing Vessel at Anchor and Attached to Fishing Gear.

VESSELS' LIGHTS

Third. **Vessels under oars or sails of less than twenty tons** shall have ready at hand a lantern with a green glass on one side and a red glass on the other, which, on the approach of or to other vessels, shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side nor the red light on the starboard side.

Fourth. **Rowing boats**, whether under oars or sail, shall have ready at hand a lantern showing a white light which shall be temporarily exhibited in sufficient time to prevent collision.

The vessels referred to in this article shall not be obliged to carry the lights prescribed by article four (a) and article eleven, last paragraph.

Lights for Pilot-vessels.

Art. 8. **Pilot-vessels** when engaged on their stations on pilotage duty shall not show the lights required for other vessels, but shall carry a *white light* at the masthead, visible all around the horizon,[7] and shall also exhibit a *flare-up light* or flare-up lights at short intervals, which shall never exceed fifteen minutes.

NOTE 7.—This may be mistaken for a steamer's masthead light.

On the near approach of or to other vessels they shall have their side-lights lighted, ready for use, and shall flash or show them at short intervals, to indicate the direction in which they are heading, but the green light shall not be shown on the port side, nor the red light on the starboard side.

A pilot-vessel of such a class as to be obliged to go alongside of a vessel to put a pilot on board may show the white light instead of carrying it at the masthead, and may, instead of the colored lights above-mentioned, have at hand, ready for use, a lantern with green glass on the one side and a red glass on the other, to be used as prescribed above.

Pilot-vessels, when not engaged on their station on pilotage duty, shall carry lights similar to those of other vessels of their tonnage.

Lights for Pilot-Vessels.

Art. 8. **Pilot-vessels** when engaged on their station on pilotage duty shall not show the lights required for other vessels, but shall carry a *white light at the masthead,* visible all around the horizon, and shall also exhibit a *flare-up light* or flare up lights at short intervals, which shall never exceed fifteen minutes.

On the near approach of or to other vessels they shall have their side-lights lighted, ready for use, and shall flash or show them at short intervals, to indicate the direction in which they are heading, but the green light shall not be shown on the port side, nor the red light on the starboard side.

A pilot-vessel of such a class as to be obliged to go alongside of a vessel to put a pilot on board may show the white light instead of carrying it at the masthead, and may, instead of the colored lights above-mentioned, have at hand, ready for use, a lantern with a green glass on the one side and a red glass on the other, to be used as prescribed above.

Pilot-vessels when not engaged on their station on pilotage duty, shall carry lights similar to those of other vessels of their tonnage.

A steam pilot-vessel, when engaged on her station on pilotage duty and *in waters of the United States,* and not at anchor, shall, in addition to the lights required for all pilot boats, carry at a distance of eight feet below her white mast-head light *a red light,* visible all around the horizon and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles, and also the colored *side-lights* required to be carried by vessels when under way.

When engaged on her station on pilotage duty and in waters of the United States, and at anchor, she shall carry in addition to the lights required for all pilot boats the red light above-mentioned, but not the colored side-lights. When not engaged on her station on pilotage duty, she shall carry the same lights as other steam-vessels.

NOTE 8.—This Rule was adopted by the United States in 1900. A similar Rule has been adopted by Great Britain, but not by other Maritime Powers. Thus the rule is not, in fact, International.

Lights, etc., of Fishing Vessels.

Art. 9. Fishing-vessels and fishing boats, when under way, and when not required by this article to carry or show the lights hereinafter specified, shall carry or show the lights prescribed for vessels of their tonnage under way.

(a) **Open boats,** by which is to be understood boats not protected from the entry of sea water by means of a continuous deck, when engaged in **any** fishing at night, with outlying tackle extending not more than one hundred and fifty feet horizontally from the boat into the seaway, shall carry *one all-round white light.*

Open boats, when fishing at night, with outlying tackle extending more than one hundred and fifty feet horizontally from the boat into the seaway, shall carry *one all-round white light,* and in addition, on approaching or being approached by other vessels, shall show *a second white light* at least three feet below the first light and at a horizontal distance of at least five feet away from it **in the direction in which the outlying tackle is attached.**

(b) Vessels and boats, except open boats as defined in subdivision (a), when fishing with **drift-nets,**[10] shall, so long as the nets are wholly or partly in the water, carry *two white lights* where they can best be seen. Such lights shall be placed so that the vertical distance between them shall be not less than six feet and not more than fifteen feet, and so that the horizontal distance between them, measured in a line with the keel, shall be not less

A steam pilot-vessel, when engaged on her station on pilotage duty and in waters of the United States, and *not at anchor,* shall, in addition to the lights required for all pilot-boats, carry at a distance of eight feet below her white masthead light a *red light,* visible all around the horizon and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles, and also the colored *side-lights* required to be carried by vessels when under way.

When engaged on her station on pilotage duty and in waters of the United States, and *at anchor,* she shall carry in addition to the lights required for all pilot-boats the *red light* above-mentioned, but not the colored side-lights.

When not engaged on her station on pilotage duty, she shall carry the same lights as other steam-vessels.

Lights, Etc., of Fishing-Vessels.

Art. 9. (a) Fishing-vessels of less than ten gross tons, when under way and when not having their nets, trawls, dredges, or lines in the water, shall not be obliged to carry the colored side-lights; but every such vessel shall, in lieu thereof, have ready at hand a lantern with a green glass on one side and a red glass on the other side, and on approaching to or being approached by another vessel such lantern shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side nor the red light on the starboard side.

(b) All fishing-vessels and fishing-boats of ten gross tons or upward, when under way and when not having their nets, trawls, dredges, or lines in the water, shall carry and show the same lights as other vessels under way.

than five feet and not more than ten feet. The lower of these two lights shall be in the direction of the nets, and both of them shall be of such a character as to show all around the horizon, and to be visible at a distance of not less than three miles.

Within the Mediterranean Sea and in the seas bordering the coasts of Japan and Korea sailing fishing-vessels of less than twenty tons gross tonnage shall not be obliged to carry the lower of these two lights. Should they, however, not carry it, they shall show in the same position (in the direction of the net or gear) a white light, visible at a distance of not less than one sea mile, on the approach of or to other vessels.

(c) Vessels and boats, except open boats as defined in subdivision (a), when **line fishing** with their lines out and attached to or hauling their lines, and when not at anchor or stationary within the meaning of subdivision (h), shall carry *the same lights as vessels fishing with drift-nets.* When shooting lines, or fishing with towing lines, they shall carry the lights prescribed for a steam- or sailing-vessel under way, respectively.

Within the Mediterranean Sea and in the seas bordering the coasts of Japan and Korea sailing fishing-vessels of less than twenty tons gross tonnage shall not be obliged to carry the lower of these two lights. Should they, however, not carry it, they shall show in the same position (in the direction of the lines) a white light, visible at a distance of not less than one sea mile on the approach of or to other vessels.

Note 10.—A distinction is drawn in Art. 9 between two important methods of fishing.—*Trawlers, dredgers,* and *drag-net* fishers, run usually with the tide, dragging a net or scoop along the bottom. Their speed, under favorable circumstances, rarely exceeds two or three knots, and their power of manœuvring is of course very limited. These vessels are usually of considerable size (from 50 to 100 tons), and their work is carried on in deep water and often at great distances from shore. If the trawl or dredge catches on the bottom, the vessel is virtually at anchor, and shows the regular anchor lights.

Fishing by *drift-nets* and *lines* is carried on by vessels drifting, and, of course, unable to manœuvre for the avoidance of collision.

Drift-nets are laid out with the wind and the vessel rides head to wind to leeward of her nets, which may be as much as two miles in length, stretching off to windward, and buoyed at certain distances. *Lines* are laid out across the tide, and may be six or eight miles in length, marked at intervals by small buoys carrying flags. These buoys are not to float the line, but only to mark it. At the end of the

(c) All vessels, when **trawling, dredging, or fishing with any kind of drag-nets or lines,** shall exhibit, from some part of the vessel where they can be best seen, *two lights.* One of these lights shall be *red* and the other shall be *white.* The red light shall be *above the white light,* and shall be at a vertical distance from it of not less than six feet and not more than twelve feet; and the horizontal distance between them, if any, shall not be more than ten feet. These two lights shall be of such a character and contained in lanterns of such construction as to be visible all round the horizon, the white light a distance of not less than three miles and the red light of not less than two miles.

line is a light anchor or other weight, which drags along the bottom, keeping the lines well down but not holding the boat.

Drift-net fishing is principally done by night, line fishing by day, trawling by both night and day.

The methods of fishing to which this article applies are carried on by many thousands of vessels along the coasts of Europe north of Cape Finisterre, in certain parts of the Mediterranean, and in the waters of China and Japan.

(d) Vessels when engaged in **trawling**, by which is meant the dragging of an apparatus along the bottom of the sea—

First. *If steam-vessels* shall carry in the same position as the white light mentioned in article two (a) *a tri-colored lantern* so constructed and fixed as to show a *white light* from right ahead to two points on each bow, and *a green light and a red light* over an arc of the horizon from *two points on each bow to two points abaft the beam* on the starboard and port sides, respectively; and not less than six nor more than twelve feet below the tri-colored lantern a *white light* in a lantern, so constructed as to show a clear, uniform, and unbroken light *all around the horizon.*

Second. *If sailing-vessels,* shall carry a white light in a lantern, so constructed as to show a clear, uniform, and unbroken light all around the horizon, and shall also, on the approach of or to other vessels, show where it can best be seen a white *flare-up light* or torch in sufficient time to prevent collision.

All lights mentioned in subdivision (d) first and second shall be visible at a distance of at least two miles.

(e) **Oyster dredgers** and other vessels fishing with dredge-nets shall carry and show the same lights as trawlers.

(f) Fishing-vessels and fishing boats may at any time use a flare-up light in addition to the lights which they are by this article required to carry and show, and they may also use working lights.

(g) Every fishing-vessel and every fishing boat under one hundred and fifty feet in length, *when at anchor,* shall exhibit a white light visible all around the horizon at a distance of at least one mile.

Every fishing-vessel of one hundred and fifty feet in length or upward, *when at anchor,* shall exhibit a white light visible all around the horizon at a distance of at least one mile, and shall

Lights for Rafts or Other Craft Not Pro

(d) Rafts, or other water craf provided for, navigating by horse-power, or by the current shall carry one or more good w which shall be placed in such ma be prescribed by the Board of Sup spectors of Steam Vessels.

exhibit a second light as provided for vessels of such length by article eleven.

Should any such vessel, whether under one hundred and fifty feet in length or of one hundred and fifty feet in length or upward, be attached to a net or other fishing gear, she shall on the approach of other vessels show *an additional white light* at least three feet below the anchor light, and at a horizontal distance of at least five feet away from it **in the direction of the net or gear.**

(h) If a vessel or boat when fishing becomes stationary in consequence of her gear getting fast to a rock or other obstruction, she shall in daytime haul down the day signal required by subdivision (k); at night show the light or lights prescribed for a vessel at anchor; and during fog, mist, falling snow, or heavy rainstorms make the signal prescribed for a vessel at anchor. (See subdivision (d) and the last paragraph of article fifteen.)

Fog-Signals for Vessels Fishing.

(i) In fog, mist, falling snow, or heavy rainstorms drift-net vessels attached to their nets, and vessels when trawling, dredging, or fishing with any kind of drag net, and vessels line fishing with their lines out, shall, if of twenty tons gross tonnage or upward, respectively, at intervals of not more than one minute make a *blast;* if steam-vessels, with the whistle or siren, and if sailing-vessels, with the fog-horn, *each blast to be followed by ringing the bell.* Fishing-vessels and boats of less than twenty tons gross tonnage shall not be obliged to give the above-mentioned signals; but if they do not, they shall make some other efficient sound signal at intervals of not more than one minute.

(k) All vessels or boats fishing with nets or lines or trawls, when under way, shall in daytime indicate their occupation to an approaching vessel by displaying a *basket* or other efficient signal where it can best be seen. If vessels or boats at anchor have their gear out, they shall, on the approach of other vessels, show the same signal *on the side on which those vessels can pass.*

The vessels required by this article to carry or show the lights hereinbefore specified shall not be obliged to carry the lights prescribed by article four (a) and the last paragraph of article eleven.

Lights for an Overtaken Vessel.

Art. 10. A vessel which is being **overtaken** by another shall show from her stern to such last-mentioned vessel a *white light* or a flare-up light.

The white light required to be shown by this article may be fixed and carried in a lantern, but in such case the lantern shall be so constructed, fitted, and screened that it shall throw an unbroken light over an arc of the horizon of twelve points of the compass, namely, for six points from right aft on each side of the vessel, so as to be visible at a distance of at least one mile. Such light shall be carried as nearly as practicable on the same level as the side-lights.

Anchor Lights.

Art. 11. A vessel under one hundred and fifty feet in length, when at anchor,[11] shall carry forward, where it can be best seen, but at a height not exceeding twenty feet above the hull, a *white light* in a lantern so constructed as to show a clear, uniform, and unbroken light visible all around the horizon at a distance of at least one mile

A vessel of one hundred and fifty feet or upwards in length, when at anchor, shall carry in the forward part of the vessel, at a height of not less than twenty and not exceeding forty feet above the hull, *one such light,* and at or near the stern of the vessel, and at such a height that it shall be not less than fifteen feet lower than the forward light, *another such light.*

The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

A vessel **aground** in or near a fair-way shall carry the above light or lights and the two red lights prescribed by article four (a).

NOTE 11.—A vessel is at anchor under the law when she is fixed by some means to the soil, when she is made fast to a buoy which is itself fixed to the soil, and when she is moored to a dock. (See the definition of "under way" in the preliminary clause of these rules.)

Lights for an Overtaken Vessel.

Art. 10. A vessel which is being **overtaken** by another, except a steam-vessel with an after range-light showing all around the horizon, shall show from her stern to such last-mentioned vessel a *white light or a flare-up light.*

Anchor Lights.

Art. 11. A vessel under one hundred and fifty feet in length **when at anchor** shall carry forward, where it can *best be* seen, but at a height not exceeding twenty feet above the hull, a *white light,* in a lantern so constructed as to show a clear, uniform, and unbroken light visible all around the horizon at a distance of at least one mile.

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The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

NOTE 12.—As the Inland Rules do not prescribe special lights for a vessel aground, such a vessel must, in United States inland waters, show the lights of a vessel at anchor.

Special Signals.

Art. 12. Every vessel may, if necessary in order to attract attention, in addition to the lights which she is by these rules required to carry, show a *flare-up light* or use any detonating signal that can not be mistaken for a distress signal.[13]

NOTE 13.—This is useful to attract the attention of a ship whose duty is to keep clear, if she does not show a disposition to act.

Naval Lights and Recognition Signals.

Art. 13. Nothing in these rules shall interfere with the operation of any special rules made by the Government of any nation with respect to additional station and signal-lights for two or more ships of war or for vessels sailing under convoy, or with the exhibition of recognition signals adopted by ship owners, which have been authorized by their respective Governments and duly registered and published.

Steam-vessel under Sail by Day.

Art. 14. A steam-vessel proceeding under sail only **but having her funnel up**, shall carry in day-time, forward, where it can best be seen, *one black ball or shape* two feet in diameter.

III.—SOUND SIGNALS FOR FOG, AND SO FORTH.

Preliminary.

Art. 15. All signals prescribed by this article for vessels under way shall be given:

First. By "steam-vessels" on the whistle or siren.

Second. By "sailing-vessels" and "vessels towed" on the fog horn.

The words *"prolonged blast"* used in this article shall mean a blast of from four to six seconds' duration.

A steam-vessel shall be provided with an efficient whistle or siren, sounded by steam or by some substitute for steam, so placed that the sound may not be intercepted by any obstruction, and with an efficient fog-horn, to be sounded by mechanical means, and also with an efficient bell. (In all cases where the rules require a bell to be used a drum may be substituted on board Turkish vessels, or a gong where such articles are used on board small sea-going vessels.) A sailing-vessel of twenty tons gross tonnage or upward shall be provided with a similar fog-horn and bell.

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The words "prolonged blast" used in this article shall mean a blast *of from four to six seconds duration.*

A steam-vessel shall be provided with an efficient whistle or siren, sounded by steam or by some substitute for steam, so placed that the sound may not be intercepted by any obstruction, and with an efficient fog-horn; also with an efficient bell. A sailing-vessel of twenty tons gross tonnage or upward shall be provided with a similar fog-horn and bell.

NOTE 14.—It is not easy to say what an "efficient" signal should be capable of doing; but we may probably insist that, under reasonably favorable conditions of wind and weather, a whistle should be heard not less than two miles, a fog-horn and bell not less than one mile. It would, however, be dangerous to rely upon hearing signals at these or any other definite distances, so many and so seemingly erratic are the atmospheric conditions which modify the audibility of sound. A sound which, under most circumstances, would be clearly heard several miles, may, by some peculiar conditions of the atmosphere, be inaudible at a quarter of a mile. It is fairly well established, that sounds are heard rather better in a fog or snow than in clear weather (other things being equal); that sound travels better with the wind than against it; that a strong breeze breaks up all sounds, and that when the upper and lower strata of air are moving in contrary directions, sounds are particularly unreliable.

In fog, mist, falling snow, or heavy rainstorms, whether by day or night, the signals described in this article shall be used as follows, namely:

Steam-vessel under Way.

(a) A steam-vessel **having way upon her** shall sound, at intervals of not more than two minutes, a *prolonged blast.*[15]

NOTE 15.—It is clear that the blast from a whistle might be so prolonged or so frequent as to lessen unduly the probability of hearing a signal from another vessel. There is also, no doubt, some danger that the hearing of an officer on the bridge may be in a measure dulled by the too frequent sound of his own whistle.

It will be agreed by most seamen, however, that two minutes is much too long a time between signals; and the general practice of men-of-war and well regulated merchant steamers seems to be to make this interval, as nearly as may be, one minute, and to give the blast a length of from four to six seconds.

There are electrical devices on the market, by which the whistle is sounded automatically, at regular intervals and for a fixed length of time, thus relieving the officer of the watch and the quartermaster of all thought in the matter, and leaving them free to give their undivided attention to duties from which, in a fog, they never should be diverted.

The interval between signals is closely connected with the question of speed in a fog.

(b) A steam-vessel under way, **but stopped,** and having no way upon her, shall sound, at intervals of not more than two minutes, *two prolonged blasts,* with an interval of about one second between.

In fog, mist, falling snow, or heavy rainstorm
or night, the signals described in this article sh
lows, namely:

Steam-Vessels Under Way.

(a) A steam-vessel **under way** shall sound,
more than **one** minute, *a prolonged blast.*

NOTE 16.—In United States inland waters no s
vided for a vessel *under way, but having no wa*
vessel uses the regular signal for a vessel under

NOTE 17.—The power to distinguish, in a fog, between a vessel moving and one stationary, is very important. Properly used, this signal should be interpreted by another vessel hearing it, to mean, "The way is off my ship; you may feel your way past me."

A caution is required in connection with the interval (two minutes) permitted between signals. The law probably intended to require that a steamer, having thus indicated that she is stationary, should remain so until she gives another signal and a different one—in other words, if a vessel which has been stationary, starts her engines, she should, by the time she gathers way, give the signal for a vessel moving, *without reference to the interval which has elapsed since her last signal.* Otherwise, she might gather way and actually move a considerable distance before indicating to vessels in her vicinity that she was no longer at rest and in the position where they would have every reason for placing her.

It is important to note that from the time two vessels sight each other, the sound signals of this article give way to the sound signals of Art. 28 for "Vessels in sight of each other."

Sail-vessel under Way.

(c) A *sailing-vessel* under way shall sound, at intervals of not more than one minute:

When on the **starboard tack,** *one blast.*

When on the **port tack,** *two blasts* in succession.

When with the wind **abaft the beam,** *three blasts* in succession.

(d) A vessel when at **anchor** shall, at intervals of not more than one minute, *ring the bell rapidly for about five seconds.*

Vessels Towing or Towed and Vessels Unable to Manœuvre.

(e) A vessel when **towing,**[18] a vessel employed in laying or in picking up a **telegraph cable,** and a vessel under way, which is unable to get out of the way of an approaching vessel through being **not under command,** or unable to manœuvre as required by the rules, shall, instead of the signals prescribed in subdivisions (a) and (c) of this article, at intervals of not more than two minutes, sound three blasts in succession, namely: *One prolonged blast followed by two short blasts.* A vessel towed may give this signal and she shall not give any other.

NOTE 18.—Observe that a vessel towing is here classed with vessels unable to manœuvre in accordance with these rules when "in a fog, mist, falling snow, or heavy rainstorm." We shall see, however (Art. 16), that she is not relieved from the obligations laid upon

Sail-Vessels Under Way.

(c) **A sailing-vessel** under way shall sound, at intervals of not more than **one** minute, when on the *starboard tack, one blast;* when on the *port tack, two blasts* in succession, and when with the *wind abaft the beam, three blasts* in succession.

Vessels at Anchor.

(d) A vessel when **at anchor** shall, at intervals, of not more than one minute, *ring the bell rapidly for about five seconds.*

Vessels Towing or Towed.

(e) A *steam*-vessel when **towing**, shall, instead of the signals prescribed in subdivision (a) of this article, at intervals of not more than **one** minute, sound *three blasts in succession, namely, one prolonged blast followed by two short blasts.*

A vessel towed may give this signal and she shall not give any other.

NOTE 19.—In United States inland waters no signal is provided for a vessel *not under command.*

Rafts or Other Craft Not Provided For.

(f) All rafts or other water craft, not herein provided for, navigating by hand-power, horse-power, or by the current of the river, shall sound a blast of the fog-horn, or equivalent signal, at intervals of not more than one minute.

other vessels, of running at a moderate speed, stopping in case of danger, and proceeding with caution; nor from the obligations as to manœuvring which are prescribed for steam-vessels meeting and crossing. It is evident, however, that a vessel with another vessel in tow is not by any means as free to manœuvre as if she were unincumbered. She can not stop and back as readily as other vessels, and even if she does this herself, she is powerless to stop or back the tow. It has been repeatedly held by the courts that other vessels are bound to take these limitations into account and to make due allowance for them, not only in a fog, but at all other times. In other words a towing-vessel must, *as far as possible,* comply with the Rules; but other vessels must not expect her to do things *which are manifestly impossible.*

The fog-signal prescribed for a vessel towing, and the lights which such a vessel shows at night, are therefore to be regarded as throwing upon other vessels an obligation to manœuvre with especial caution. And this obligation is of course greater in a fog than at any other time.

Small Sailing-vessels and Boats.[20]

Sailing-vessels and boats of less than twenty tons gross tonnage shall not be obliged to give the above-mentioned signals, but if they do not they shall make some other efficient sound-signal at intervals of not more than one minute.

NOTE 20.—See Art. 9 for the fog-signals to be used by fishing-vessels.

FOG SIGNALS.

——— LONG BLAST — SHORT BLAST.

STEAM VESSEL HAVING WAY UPON HER	———
STEAM VESSEL UNDERWAY BUT STOPPED and HAVING NO WAY UPON HER	——— 1 Second Interval ———
SAILING VESSEL UNDERWAY	
On Starboard Tack	———
On Port Tack	——— ———
With Wind Abaft Beam	——— ——— ———
VESSEL TOWING VESSEL TOWED VESSEL NOT UNDER COMMAND VESSEL WORKING WITH TELEGRAPH CABLE	——— — —

NOTE—The International Rules require the above signals to be sounded at intervals not exceeding 2 minutes, the United States Inland Rules at intervals not exceeding 1 minute.

VESSEL AT ANCHOR	Ring BELL rapidly for 5 seconds (at intervals of 1 minute).
VESSEL FISHING	——— Blast Ring Bell.

SOUND SIGNALS.

FOR VESSELS IN SIGHT OF EACH OTHER.

—	I am directing my course to starboard.
— —	I am directing my course to port.
— — —	My engines are going Full Speed Astern.

NOTE—The significance attached to these signals in the Pilot Rules for United States Inland waters is slightly different from the above.

(See Notes 29 and 31, Chapter XIV, Art. 19.)

Speed in Fog.

Art. 16. Every vessel shall, in a fog, mist, falling snow, or heavy rainstorms, go at a **moderate speed,** having careful regard to the existing circumstances and conditions.[21]

A steam-vessel hearing, apparently forward of her beam, the fog-signal of a vessel the position of which is not ascertained, shall, so far as the circumstances of the case admit, stop her engines, and then navigate with caution until danger of collision is over.[23, 24]

NOTE 21.—There is no point in connection with seamanship or admiralty law about which there has been as much discussion as about this question of "moderate speed" in a fog. The debates on it fill a hundred pages or more in the report of the International Marine Conference by which the present rules were drawn up. It was contended that a law upon which so much depended ought not to be left open to any doubt; and that the maximum speed at which a vessel might run in a fog should be definitely fixed by a law which no one could violate except willfully and at his peril.

This subject will be treated as a matter of seamanship in a later chapter. As a matter of law, it may be said that the courts of both England and America have held that "moderate" speed is such speed as will enable a vessel to bring herself to rest before coming into collision with any other vessel which she can sight through the fog in its existing condition, assuming that the other vessel is also running at a proper speed under this Rule, and that both vessels act promptly to prevent collision. In a dense fog, this calls for the very lowest speed which is consistent with steerage way; and steamers have been found at fault when running less than five knots. If the fog is so dense that a ship which has barely steerage way and a good reserve of power can not see another in time to avoid her even at that low speed, then the law requires vessels to stop, and, if circumstances permit it, to anchor. This is unquestionably the *law* in the matter, and we are not at present considering its wisdom, or the general practice of seamen in connection with it.

On the other hand, it has been held by the courts of both England and the United States that a higher speed is permissible in the open sea, where the probability of falling in with other ships is very slight, than in crowded waters or on fishing grounds. When in the neigh-

Speed in Fog.

Art. 16. Every vessel shall, in a fog, mist, falling snow, or heavy rainstorms, go at a **moderate speed**, having careful regard to the existing circumstances and conditions.

A steam-vessel hearing, apparently forward of her beam, the fog-signal of a vessel the position of which is not ascertained shall, so far as the circumstances of the case admit, stop her engines, and then navigate with caution until danger of collision is over.

NOTE 22.—See Note 21 under International Rules, and § IV at end of this Chapter.

borhood of shoals and particularly in channels where currents are strong and unknown, it may be dangerous to slow beyond a certain point, and a court would doubtless accept such a plea as a valid reason for maintaining a speed which under other circumstances would be excessive. This is fully covered by the phrase "having careful regard to the existing circumstances and conditions." But the burden of proof is thrown upon the ship maintaining such speed. There can be no question that the custom commonly followed by the great ocean liners, of running through dense fogs at a speed only a few knots below their maximum, is, in the eyes of the law, altogether unjustifiable.

This subject is one of such importance, and the views held by seafaring men with regard to it are so vague, that it is considered worth while to append (in § IV at end of this Chapter) a number of decisions of the courts dealing with the subject. These decisions will be found recorded. in conveniently accessible form, in the files of the "**Federal Reporter,**" which can be seen in almost any large library.

Note 23.—It should be noted that the *ship* need not be stopped immediately, but the *engines* must be. If, later, the danger appears such that the ship should be stopped, there will be a reserve of steam ready for backing hard. The objection to backing the engines before the location of the danger is fixed, is that by doing so the control of the ship by the helm is to a great extent destroyed.

Note 24.—It is clear that this rule could not safely be applied by the individual vessels of a squadron of men-of-war steaming in formation in a fog. Each vessel under such circumstances must have due regard to her neighbors in squadron as well as to other vessels which may be near. The case is covered by the words "so far as the circumstances of the case admit."

IV.—STEERING AND SAILING RULES.

Preliminary—Risk of Collision.

Risk of collision can, when circumstances permit, be ascertained by carefully watching the compass bearing of an approaching vessel. **If the bearing does not appreciably change,** such risk should be deemed to exist.[25]

NOTE 25.—*The principle involved here is one of such vital importance that it should be very carefully impressed upon all officers.* If the bearing of the other vessel is changing materially, there is no danger of collision. If it is not changing materially, collision is certain to result unless one vessel changes course or speed. The fact that the bearing is not changing indicates that both vessels are due to arrive at the same time at the point where their courses intersect. If either vessel changes course or speed (materially) the danger will be averted. If both vessels change, the danger may remain. It is for this reason that the law provides (Art. 21) that the vessel which has the other on her own port side shall keep her course and speed. Assuming that this requirement is complied with, practically any change on the part of the other vessel should make the situation safe, but the law has wisely provided (Art. 22) that she shall, if possible, avoid crossing ahead.

The practical way to determine whether the bearing is or is not changing, is to stand at a point from which the compass can be watched, and then, taking care that a steady course is steered, bring the other vessel or light "on" with a point of the rigging or the rail, and watch thus for a change in its bearing.

There are, of course, many cases in which there is no time to wait for a change in bearing; but in cases of such emergency as this, the ships are close enough together to make the danger clear at a glance, and there is rarely more than one course of action that can give a hope of safety.

It is of course not necessary to wait for the side-light of a steamer to show. The masthead light should be visible five miles, and if it shows at anything like this distance the warning of danger, assuming that such exists, will be perfectly clear long before the side-lights are made out.

Sailing-vessels.

Art. 17. When two sailing-vessels are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other as follows, namely:

(a) A vessel which is running free shall keep out of the way of a vessel which is close-hauled.

IV.—STEERING AND SAILING RULES.

Preliminary—Risk of Collision.

Risk of collision can, when circumstances permit, be ascertained by carefully watching the compass bearing of an approaching vessel. If the bearing does not appreciably change such risk should be deemed to exist.

NOTE 26.—See Note 25 under corresponding paragr ternational Rules.

'essels Meeting or Crossing.

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›se-hauled.

(b) A vessel which is close-hauled on the port tack shall keep out of the way of a vessel which is close-hauled on the starboard tack.

(c) When both are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.

(d) When both are running free, with the wind on the same side, the vessel which is to the windward shall keep out of the way of the vessel which is to leeward.

(e) A vessel which has the wind aft shall keep out of the way of the other vessel.[26]

NOTE 26.—These rules are simple and satisfactory when the situations to which they apply are clearly defined. But in practice it is often impossible for *A* to tell with any degree of certainty whether *B* is close-hauled or a little free; and yet the action to be taken by *A* may depend upon this and this alone.

A similar difficulty arises when *A*, running with the wind free on the port hand, sights *B*, to port and running free, and cannot tell on which side *B* has the wind. If she has it on the starboard side, *A* must keep clear, under rule (c); if on the port side, *A* has the right of way and *B* must keep clear under rule (d), because she is to windward of *A*.

No doubt a rational interpretation of this rule would require *B* to keep clear in most of these doubtful cases, on the ground that she would have the wind so nearly aft that it should be considered aft in the meaning of the law.

An officer taking charge of the deck of a sailing ship should estimate carefully the true direction of the wind and consider what conclusions may be based upon this with regard to the possible or probable course of other vessels whose lights may be sighted ahead or on either hand. Remembering that a square rigger can not lie closer to the wind than 6 points and that side-lights show through a range of ten points, from right ahead to two points abaft the beam, he will have much information upon which to base an opinion as to the way in which a ship may be heading which is seen on a given bearing, showing a red or green light. If his own ship is close-hauled on the port tack, he has the right of way over all other vessels except one close-hauled on the starboard tack, and it is clear that such a vessel, to threaten collision, must bear a little on the lee bow and must show a red light. In a similar way, deductions may be drawn from the data available in any given case, and, usually, a line of bearing may be decided upon, with reference to which it may be said that, broadly speaking, it is right to stand on for all *crossing* lights seen on one side of this line, and to give way to all *crossing* lights seen on the other side.

(b) A vessel which is close-hauled on the port tack shall keep out of the way of a vessel which is close-hauled on the starboard tack.

(c) When both are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.

(d) When both are running free, with the wind on the same side, the vessel which is to the windward shall keep out of the way of the vessel which is to *the* leeward.

(e) A vessel which has the wind aft shall keep out of the way of the other vessel.

Steam-vessels Meeting.

Art. 18. When two steam-vessels are meeting end-on, or nearly end-on, so as to involve risk of collision, **each shall alter her course to starboard,** so that each may pass on the port side of the other.

This article only applies to cases where vessels are meeting end-on, or nearly end-on, in such a manner as to involve the risk of collision, and does not apply to two vessels which must, if both keep on their respective courses pass clear of each other.

The only cases to which it does apply are when each of the two vessels is end-on or nearly end-on, to the other; in other words, to cases in which, by day, each vessel sees the masts of the other in a line or nearly in a line with her own; and by night to cases in which each vessel is in such a position as to see both the side-lights of the other.

It does not apply by day to cases in which a vessel sees another ahead crossing her own course; or by night, to cases where the red light of one vessel is opposed to the red light of the other, or where the green light of one vessel is opposed to the green light of the other, or where a red light without a green light, or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.[27]

NOTE 27.—The wording of this article is necessarily somewhat indefinite, and leaves room for a difference in the interpretation of the situation on the part of two vessels approaching each other, "nearly end-on," but not exactly so. If one vessel considers that the situation is a case of "meeting," as here defined, while the other considers it one of "crossing," there may be such a conflict of action between them as will lead to serious danger, especially if it happens that each vessel is, in reality, a little on the starboard bow of the other.

Many seamen consider a green light *a very little* on the starboard bow the most serious threat of collision with which they have to deal.

The great safeguard, in this and other doubtful cases, lies in an interchange of sound-signals while the vessels are still separated by a safe distance, and in prompt action in accordance with the understanding thus established.

Steam-Vessels Meeting.

Art. 18. When steam vessels are approaching each other **head and head,** that is, end on, or nearly so, it shall be the duty of each to pass on the port side of the other; and either vessel shall give, as a signal of her intention, *one short and distinct blast* of her whistle, which the other vessel shall answer promptly by a similar blast of her whistle, and thereupon such vessels shall pass on the port side of each other. But if the courses of such vessels are so far on the starboard of each other as not to be considered as meeting head and head, either vessel shall immediately give *two short and distinct blasts of her whistle,* which the other vessel shall answer promptly by two similar blasts of her whistle, and they shall pass on the starboard side of each other.

The foregoing only applies to cases where vessels are meeting end on or nearly end on, in such a manner as to involve risk of collision; in other words, to cases in which, by day, each vessel sees the masts of the other in a line, or nearly in a line, with her own, and by night to cases in which each vessel is in such a position as to see both the side-lights of the other.

It does not apply by day to cases in which a vessel sees another ahead crossing her own course, or by night to cases where the red light of one vessel is opposed to the red light of the other, or where the green light of one vessel is opposed to the green light of the other, or where a red light without a green light or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.

The following have no parallel in the International Rules:

Nearing a Bend or Leaving a Slip.

Whenever a steam-vessel is **nearing a short bend or curve in the channel,** where, from the height of the banks or other cause, a steam-vessel approaching from the opposite direction can not be seen for a distance of half a mile,

Plate No. 124.

RANGE LIGHTS.

STEAMERS MEETING.

mile, such steam-vessel, when she shall have arrived within half a mile of such curve or bend, shall give a signal by **one long blast** of the steam-whistle, which signal shall be answered by a similar blast, given by any approaching steam-vessel that may be within hearing. Should such signal be so answered by a steam-vessel upon the farther side of such bend, then the usual signals for meeting and passing shall immediately be given and answered; but, if the first alarm signal of such vessel be not answered, she is to consider the channel clear and govern herself accordingly.

When steam-vessels are **moved from their docks or berths,** and other boats are liable to pass from any direction toward them, they shall give the *same signal as in the case of vessels meeting at a bend,* but immediately after clearing the berths so as to be fully in sight they shall be governed by the steering and sailing rules. (See remarks in § III of this chapter on "Vessels Backing.")

Passing a Vessel Going in Same Direction.

When steam-vessels are running in the same direction, and the vessel which is astern shall desire **to pass on the right** or starboard hand of the vessel ahead, she shall give *one short blast* of the steam-whistle, as a signal of such desire, and if the vessel ahead answers with one blast, she shall put her helm to port; or if she shall desire **to pass on the left** or port side of the vessel ahead, she shall give *two short blasts* of the steam-whistle as a signal of such desire, and if the vessel ahead answers with two blasts, shall put her helm to starboard; or if the vessel ahead does not think it safe for the vessel astern to attempt to pass at that point, she shall immediately signify the same by giving *several short and rapid blasts* of the steam-whistle, not less than four, and under no circumstances shall the vessel astern attempt to pass the vessel ahead until such time as they have reached a point where it can be safely done, when said vessel ahead shall signify her willingness by blowing the proper signals. The vessel ahead shall in no case attempt to cross the bow or crowd upon the course of the passing vessel.

NOTE 28.—It is good seamanship for a vessel overtaking another from directly astern and desiring to pass her, to pass to the left rather than to the right, and for the following reason: Suppose that *A* is overtaking *B*. It may happen that while *A* is passing, *B* will meet another vessel, *C*. In this case, *B* must put her helm to port and sheer over to the right, which will throw her directly across *A's* bow if *A* is passing on that side. With *A* passing on the other side, *B's* port helm will take her clear of both *A* and *C*.

Two Steam-vessels Crossing.

Art. 19. When two steam-vessels are crossing, so as to involve risk of collision, **the vessel which has the other on her own starboard side shall keep out of the way of the other.**

NOTE 29.—In comparing the International and the Inland Rules for Vessels Meeting and Crossing, some confusion may result from the different methods of treating these situations in the two sets of Rules.

In the International Rules, the *manœuvres* for meeting vessels are prescribed in Article 18 and those for crossing vessels in Articles 19, 21 and 22. The *sound signals* for both meeting and crossing are given in Article 28.

The treatment of the matter in the Inland Rules is described in Note 31, on the opposite page.

The signals from Article 28 are quoted below as a matter of convenience and for comparison with the United States Pilot Rules on the opposite page.

From International Rules. (Art. 28).

"**One** short blast to mean, **I am directing my course to starboard.**

Two short blasts to mean, **I am directing my course to port.**

Three short blasts to mean, **My engines are going at full speed astern.**"

NOTE 30.—It should not be forgotten that sound-signals are as applicable by night as by day, and that, under favorable conditions, they can be heard nearly or quite as far as side-lights are required by law to be visible. There is, however, this important difference; that by

Two Steam-Vessels Crossing.

Art. 19. When two steam-vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other.

NOTE. 31.—(Compare with Note 29, opposite.) In the Inland Rules, Article 18 prescribes the manœuvres for vessels meeting *and also the Sound Signals to be used.* Articles 19, 21 and 22 prescribe the manœuvres for vessels crossing. But, *at no point* in the Inland Rules as enacted by Congress are the Sound Signals for crossing prescribed. For some reason, Congress thought it wise to leave these signals to be fixed by the Supervising Inspectors of Steam Vessels. Accordingly, these sound signals (for vessels crossing in United States Inland Waters) are found only in the "Pilot Rules" issued by the Steamboat Inspection Service. Altho the rules thus prescribed are in their essentials identical with the corresponding International Rules, they are unfortunately expressed in terms differing rather widely from those of the International Rules, as will be seen by comparing the following with the corresponding International Rules.

It must be understood that these rules are as much a matter of law as if they had been specifically embodied in the Act of Congress. They are, however, subject to change by the will of Supervising Inspectors of Steam-vessels.

From United States Pilot Rules

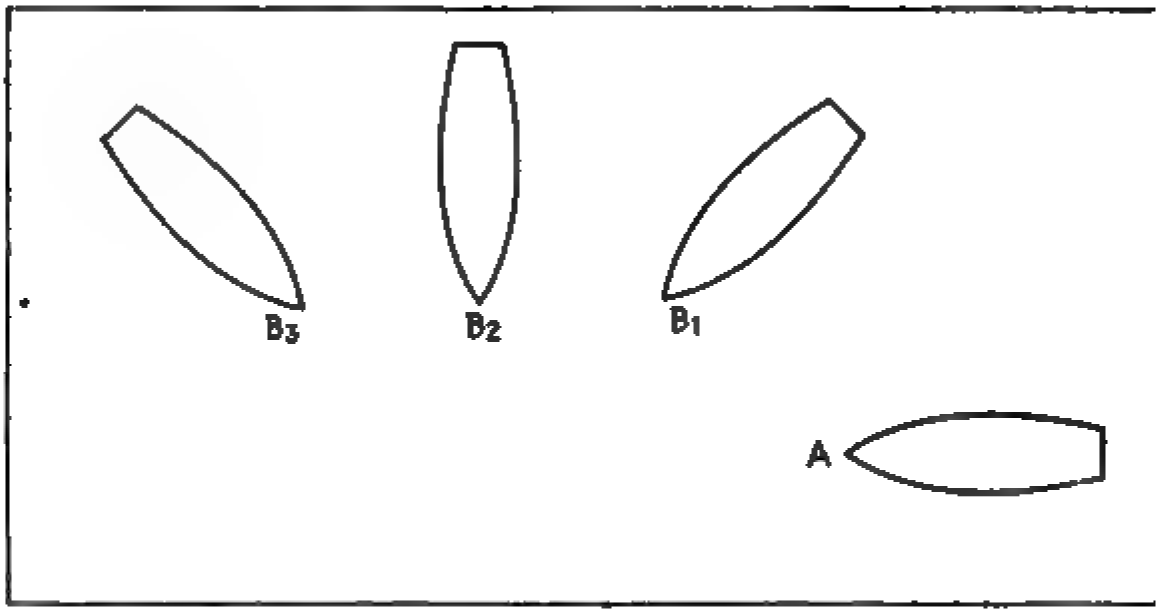
"*One short blast* of the whistle signifies intention to direct course to own starboard, except when two steam vessels are approaching each other at right angles or obliquely, when it signifies intention of the steam vessel which is to starboard of the other to hold course and speed.

Two short-blasts of the whistle signify intention to direct own course to port.

Three short blasts of the whistle shall mean, 'My engines are going at full speed astern.'"

Plate No. 125.

STEAMERS CROSSING WITH AND WITHOUT RANGE LIGHTS



CROSSING: "A" SIGHTS "B" TO STARBOARD.

RANGE LIGHTS.

STEAMERS CROSSING WITH AND WITHOUT RANGE LIGHT

day the sound of the whistle is usually confirmed by the sight of escaping steam, and seamen commonly rely almost as much upon their eyes as upon their ears for recognizing signals. By night this advantage does not exist, and greater care is called for.

The danger of misunderstanding at night is still further increased by the uncertainty existing on each ship with regard to the exact course of the other, except in case where both ships are carrying range-lights. Where range-lights are not used, it is helpful to recognize the value of the information given by a change in the side-lights seen; as, for example, a change from one light to both, or from both to one. A change in the relative positions of the side-light and the masthead light is also significant, but as there is no means of knowing whether the side-light is forward of the masthead light or abaft it, this gives no information as to the nature of the change of course which is being made.

Observe that there is nothing in Articles 18 and 19 which leaves any choice to meeting and crossing vessels with regard to the side on which they pass each other. Nevertheless, circumstances sometimes arise in which it is necessary for them to pass starboard to to starboard, and this manœuvre can be justified (but only in cases of necessity), under Art. 27. See § III of this chapter.

Additional Pilot Rules covering exceptional situations in Inland Waters.

(*a*) If, when steam-vessels are approaching each other, either vessel fails to understand the course or intention of the other, from any cause, the vessel so in doubt shall immediately signify the same by giving **several short and rapid blasts,** not less than four, of the steam-whistle.

(*b*) If from any cause whatever the conditions covered by this situation are such as to prevent immediate compliance with each other's signals, the misunderstanding or objection shall at once be made apparent by blowing the danger signal, and both steamers shall be stopped, and backed if necessary, until signals for passing with safety are made and understood.

(*c*) Steam-vessels are forbidden to use what has become technically known among "pilots" as "*Cross Signals*," that is, answering one whistle with two and answering two whistles with one.

(*d*) The signals for passing, by the blowing of the whistle, shall be given and answered by pilots, in compliance with these rules, not only when meeting "head and head," or nearly so, but at all times, when the steam vessels are in sight of each other, when passing or meeting at a distance within half a mile of each other, and whether passing to the starboard or port.

(*e*) The whistle signals provided in the rules of this article, for steam-vessels meeting, passing, or overtaking, are never to be used except when steamers are in sight of each other, and the course and position of each can be determined in the day-time by a sight of the vessel itself, or by night by seeing its signal lights. In fog, mist, falling snow or heavy rainstorms, when vessels can not see each other, fog-signals only must be given.

Steam-vessels shall keep out of the Way of Sailing-vessels.

Art. 20. When a steam-vessel and a sailing-vessel are proceeding in such directions as to involve risk of collision, the steam-vessel shall keep out of the way of the sailing-vessel.

Course and Speed.

Art. 21. Where, by any of these rules, one of the two vessels is to keep out of the way **the other shall keep her course and speed.**

Note. When, in consequence of thick weather or other causes, such vessel finds herself so close that collision can not be avoided by the action of the giving-way vessel alone, she also shall take such action as will best aid to avert collision. (See articles twenty-seven and twenty-nine.)[32]

NOTE 32.—One of the most trying positions in which an officer can find himself is that of holding on with a prospect of collision where the other vessel ought to keep clear but takes no action to do so. The impossibility of knowing whether the giving-way ship intends to act, and if so when, and the necessity of deciding when the time has come which will justify the holding-on ship in acting under this article make the situation very difficult.

The use of a detonating signal, as per article 12, may be helpful here.

Crossing Ahead.

Art. 22. Every vessel which is directed by these rules to keep out of the way of another vessel shall, if the circumstances of the case admit, **avoid crossing ahead of the other.**[33]

NOTE 33.—This article is one of the most important in the Rules of the Road, to which it was added by the International Conference of 1889.

Taken in connection with Art. 19 and with the new provision of Art. 21, by which the vessel having the right of way is required to keep her speed as well as her course, it defines very clearly the manœuvre for steamers crossing, and requires, as a matter of law, what has always been the practice of careful and competent seamen.

It is manifestly impracticable to insist that the vessel which is required to keep clear shall *never* cross ahead of the other since circumstances may in some cases make it imperative to do so; as, for example, where the vessels suddenly sight each other close aboard, or where neighboring vessels or other dangers must be taken into account. Such situations very rarely arise on the open sea, except

Steam-Vessels Shall Keep Out of the Way of Sailing-Vessels.

Art. 20. When a steam-vessel and a sailing-vessel are proceeding in such directions as to involve risk of collision, the steam-vessel shall keep out of the way of the sailing-vessel.

Course and Speed.

Art. 21. Where, by any of these rules, one of the two vessels is to keep out of the way the other shall keep her course and speed.

Crossing Ahead.

Art. 22. Every vessel which is directed by these rules to keep out of the way of another vessel shall, if the circumstances of the case admit, avoid crossing ahead of the other.

NOTE 34.—See Pilot Rules quoted under Art. 19. See also § III of this chapter.

In crowded waters, situations frequently arise in which it is essential that the burdened vessel shall cross ahead; but if collision results in such a case, the courts insist upon conclusive evidence that this was in fact the safest course. **Whatever action is to be taken, whether in crowded or in open waters, this action should be announced by the proper whistle signal.**

It seems to be believed by many officers, that a signal of two blasts by the vessel which should give away has the effect of changing the law and of justifying this vessel in crossing ahead, merely as a matter of convenience. The law on this subject is very clearly set forth in the decision quoted in § III. of this chapter.

in case of fog, and when they do arise they are fully covered by Art. 21 (International Rules), and Art. 27. It is especially important, in cases of this kind, to indicate by whistle signals the manœuvre which is to be attempted. (See § III, of this chapter.)

Steam-vessels shall slacken Speed or Stop.

Art. 23. Every steam-vessel which is directed by these rules to keep out of the way of another vessel shall, on approaching her, if necessary, slacken her speed or stop or reverse.

Overtaking Vessels.

Art. 24. Notwithstanding anything contained in these rules every vessel, overtaking any other, shall keep out of the way of the overtaken vessel.[35]

Every vessel coming up with another vessel from any direction more than two points abaft her beam, that is, in such a position, with reference to the vessel which she is overtaking that at night she would be unable to see either of that vessel's side-lights, shall be deemed to be an overtaking vessel; and no subsequent alteration of the bearing between the two vessels shall make the overtaking vessel a crossing vessel within the meaning of these rules, or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear.

As by day the overtaking vessel can not always know with certainty whether she is forward of or abaft this direction from the other vessel she should, if in doubt, assume that she is an overtaking vessel and keep out of the way.

NOTE 35 —The rule for overtaking vessels applies to sailing-vessels as well as to steamers, so that a sailing-vessel close-hauled coming up from more than two points abaft the beam of a vessel running free, must keep clear. Moreover, a sailing-vessel overtaking a steamer must keep clear. And this obligation upon the overtaking vessel to keep clear is not modified by any subsequent change in the relative position of the two vessels.

Where the crossing rule and the overtaking rule conflict—that is to say, where one vessel is both overtaking and crossing another, **the overtaking rule prevails,** so that a crossing steamer which has come up from more than two points abaft the beam of another, must keep clear, even though she is on the starboard side of the other; and she is not relieved from this obligation even after she draws ahead on to the beam and bow of the other vessel.

Steam-Vessel Shall Slacken Speed or Stop.

Art. 23. Every steam-vessel which is directed by these rules to keep out of the way of another vessel shall, on approaching her, if necessary, slacken her speed or stop or reverse.

Overtaking Vessels.

Art. 24. Notwithstanding anything contained in these rules every vessel overtaking any other, shall keep out of the way of the overtaken vessel.

Every vessel coming up with another vessel from any direction more than two points abaft her beam, that is, in such a position, with reference to the vessel which she is overtaking that at night she would be unable to see either of that vessel's side-lights, shall be deemed to be an overtaking vessel; and no subsequent alteration of the bearing between the two vessels shall make the overtaking vessel a crossing vessel within the meaning of these rules, or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear.

As by day the overtaking vessel can not always know with certainty whether she is forward of or abaft this direction from the other vessel she should, if in doubt, assume that she is an overtaking vessel and keep out of her way.

NOTE 36.—See Note 35 under Article 24, International Rules.

In cases where the crossing rule and the overtaking rule conflict, the overtaking rule prevails; so that a vessel which is both overtaking and crossing another must keep clear, even though she has the other on her port hand.

Narrow Channels.

Art. 25. In narrow channels every steam-vessel shall, when it is safe and practicable, keep to that side of the fair-way or mid-channel which lies on the starboard side of such vessel.[37]

NOTE. 37.—It is not permissible to keep to the wrong side of the channel to avoid an unfavorable current, or for any other purpose, except to avoid danger.

Rights of Way of Fishing-vessels.

Art. 26. Sailing-vessels under way shall keep out of the way of sailing-vessels or boats fishing with nets, or lines, or trawls. This rule shall not give to any vessel or boat engaged in fishing the right of obstructing a fair-way used by vessels other than fishing-vessels or boats.

General Prudential Rule.

Art. 27. *In obeying and construing these rules due regard shall be had to all dangers of navigation and collision, and to any special circumstances which may render a departure from the above rules necessary in order to avoid immediate danger.*

Narrow Channels.

Art. 25. In narrow channels every steam-vessel shall, when it is safe and practicable, keep to that side of the fair-way or mid-channel which lies on the starboard side of such vessel.

NOTE. 38.—It is not permissible to keep to the wrong side of the channel either to avoid an unfavorable current, or for any other purpose, except to avoid danger. See Note 40.

Rights of Way of Fishing-Vessels.

Art. 26. Sailing-vessels under way shall keep out of the way of sailing-vessels or boats fishing with nets, or lines, or trawls. This rule shall not give to any vessel or boat engaged in fishing the right of obstructing a fair-way used by vessels other than fishing-vessels or boats.

General Prudential Rule.[41]

Art. 27. In obeying and construing these rules due regard shall be had to all dangers of navigation and collision, and to any special circumstances which may render a departure from the above rules necessary in order to avoid immediate danger.

NOTE 40.—Although there is no provision of the law giving special privileges to ferry-boats the courts have repeatedly held that ferry-boats are entitled to reasonable freedom of entrance to, and exit from, their slips.

It is generally held, also, that vessels navigating a harbor should avoid passing close to the docks.

By a special statute of the State of New York, vessels navigating East River are required to keep as near the middle of the stream as is practicable, and not to exceed a speed of 10 knots.

NOTE. 41. It is to this Article that appeal must be made for justification of any departure from the rules elsewhere prescribed for vessels meeting or crossing. But no appeal can be successfully maintained before the Courts unless it appears clearly that the course adopted was dictated by necessity;—that it was, in fact, the only course which gave a chance of safety, or at least the one which gave the maximum chance. Neither the convenience of one or both vessels nor an agreement between them is held by the Courts to justify departure from the rules.

But see the very full discussion under § III of this chapter, where it is explained that violations of the rules by Pilots are of frequent occurrence in United States Inland waters.

Sound-signals for Vessels in Sight of One Another.[42]

Art. 28. The words "**short blast**" used in this article shall mean a blast of about one second's duration.

When vessels are in sight of one another, a steam-vessel under way, in taking any course authorized or required by these rules, shall indicate that course by the following signals on her whistle or siren, namely:

One short blast to mean, "**I am directing my course to starboard.**"

Two short blasts to mean, "**I am directing my course to port.**"

Three short blasts to mean, "**My engines are going at full speed astern.**"

NOTE 42.—It should be noted that this rule applies to vessels in sight of each other, whether by night or day, in clear or in foggy weather, but not to vessels, however close, which do not see each other or each other's lights. Thus two vessels in a fog must keep to the signals of Art. 15 until they actually see each other. Many seamen hold that there would be great advantage in the use of these signals by vessels near each other, but not in sight, in a fog, and some officers do not hesitate to use them in this way; but this is in direct defiance of the law.

No Vessel, under any Circumstances, to Neglect Proper Precautions.

Art. 29. Nothing in these rules shall exonerate any vessel or the owner or master or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper lookout, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by special circumstances of the case.

Reservation of Rules for Harbors and Inland Navigation.

Art. 30. Nothing in these rules shall interfere with the operation of a special rule, duly made by local authority, relative to the navigation of any harbor, river, or inland waters.

NOTE. 43.—In the waters of the United States there are two sets of rules "duly made by local authority"; 1st, the so-called "Inland Rules" made by Act of Congress and printed herewith; 2d, the "Pilot Rules" made by the inspectors of steam-vessels and embodied in the Inland Rules as here given.

Sound-Signals for Vessels in Sight of One Another.

Art. 28. When vessels are in sight of one another a steam-vessel under way whose engines are going at full speed astern shall indicate that fact by three short blasts on the whistle.

The following are the Pilot Rules establishing sound signals under this article.

> A *short blast* of the whistle shall mean a blast of about one second's duration.
>
> A *prolonged blast* of the whistle shall mean a blast of from four to six seconds' duration.
>
> *One short blast* of the whistle signifies intention to direct course to own starboard, except when two steam vessels are approaching each other at right angles or obliquely, when it signifies intention of steam vessel which is to starboard of the other to hold course and speed.
>
> *Two short blasts* of the whistle signify intention to direct course to own port.
>
> *Three short blasts* of the whistle shall mean, "My engines are going at full speed astern."

NOTE 44.—See the discussion of Sound Signals in Notes 29 and 31 under article 19 preceding.

No Vessel Under Any Circumstances to Neglect Proper Precautions.

Art. 29. Nothing in these rules shall exonerate any vessel, or the owner or master or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper lookout, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

Lights on Naval and Revenue Vessels.

Art. 30. The exhibition of any light on board of a vessel of war of the United States or a revenue cutter may be suspended whenever, in the opinion of the Secretary of the Navy, the commander-in-chief of a squadron, or the commander of a vessel acting singly, the special character of the service may require it.

Distress Signals.

Art. 31. When a vessel is in distress and requires assistance from other vessels or from the shore the following shall be the signals to be used or displayed by her, either together or separately, namely:

In the daytime—

First. A gun or other explosive signal fired at intervals of about a minute.

Second. The international code signal of distress indicated by N. C.

Third. The distance signal, consisting of a square flag, having either above or below it a ball or anything resembling a ball.

Fourth. A continuous sounding with any fog-signal apparatus.

At night—

First. A gun or other expolsive signal fired at intervals of about a minute.

Second. Flames on the vessel as from a burning tar barrel, oil barrel, and so forth.

Third. Rockets or shells throwing stars of any color or description, fired one at a time, at short intervals.

Fourth. A continuous sounding with any fog-signal apparatus.

Distress Signals.

Art. 31. When a vessel is in distress and requires assistance from other vessels or from the shore the following shall be the signals to be used or displayed by her, either together or separately, namely:

In the Daytime.

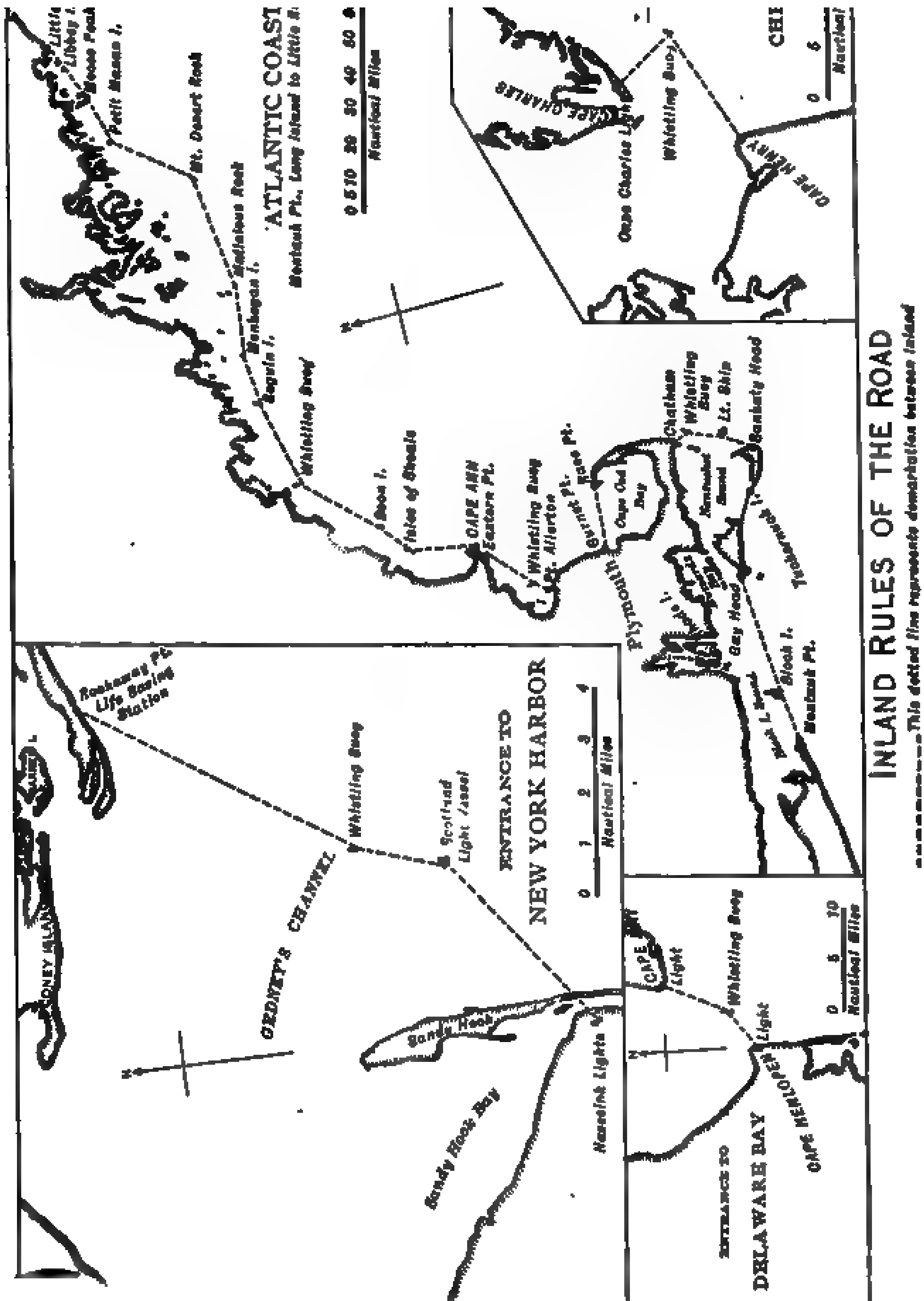
A continuous sounding with fog-signal apparatus, *or firing a gun.*

At Night.

First. Flames on the vessel as from a burning tar barrel, oil barrel and so forth.

Second. A continuous sounding with any fog-signal apparatus, *or firing a gun.*

NOTE 45.—Very important information as to the practices and methods of the United States Coast Guard in assisting vessels in distress will be found in Chapter XXIX.


INLAND RULES OF THE ROAD
This dotted line represents demarcation between inland and international Rules
ATLANTIC COAST
Nautical Miles
Petit Manan I.
Mt. Desert Rock
Matinicus Rock
Monhegan I.
Seguin I.
Whistling Buoy
Boon I.
Isles of Shoals
CAPE ANN
Eastern Pt.
Whistling Buoy
Plymouth
Cape Cod Bay
Chatham
Whistling Buoy
Sankaty Head
Gay Head
Block I.
Montauk Pt.
CAPE CHARLES
Cape Charles Light
Whistling Buoy
CAPE HENRY
Nautical Miles
ENTRANCE TO
NEW YORK HARBOR
Nautical Miles
Rockaway Pt.
Life Saving
Station
Whistling Buoy
Scotland
Light Vessel
GEDNEY'S CHANNEL
Sandy Hook
Sandy Hook Bay
Navesink Lights
ENTRANCE TO
DELAWARE BAY
CAPE
Light
Whistling Buoy
Light
CAPE HENLOPEN
Nautical Miles

§ III.

REMARKS ON THE RULES FOR STEAMERS MEETING AND CROSSING.

The rules for meeting and crossing are laid down in Articles 18, 19, 21, 22, 23, 24, 25, 27, and 28 of both the International and Inland Rules and, as regards United States inland waters, in the Pilot Rules quoted under Article 19.

GENERAL PRINCIPLES. All of the above rules are based upon one very simple principle, which is that every steamer in passing another steamer, whether in meeting or in crossing, MUST KEEP TO THE RIGHT; or, in other words, must present her own port side to the vessel which she is passing.

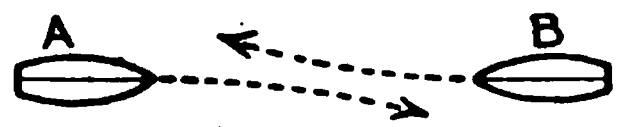
It follows that, if A and B are crossing and if A is already presenting her port side to B, she has no occasion to make a change. She therefore keeps her course and speed. It follows equally that B, since she is presenting her starboard side to A, must make a change, and this change must be of such a nature as to bring her port side toward A. This will, in general call for port helm and will swing B's head toward A's stern, although B may, of course, bring about the same result by slowing, stopping, or backing, thus allowing A to draw ahead across B's bow and toward B's port side.

If the vessels are meeting end-on, neither one is presenting her port side to the other, and each must change course to starboard, thus bringing her port side toward the other.

It has been explained, in Notes 34 and 41, that a departure from the general rule is permissible in cases of emergency, where it can be shown to give a maximum chance of avoiding collision, but not otherwise.

The law in this matter is clearly laid down in the following decisions of the United States courts:

(1) "A steamer bound to keep out of the way of another steamer by going to the right, has no right, when under no stress of circumstances, but merely for her own convenience, to give the other steamer a signal of two whistles, importing that she will go to the left, unless she can do so safely by her own navigation, without aid from the other, and without requiring the other steamer to change her course or her speed. Otherwise she would be imposing upon the latter steamer more or less of the burden and the duty of keeping out of the way, which by statute is imposed on herself. When two blasts are given under such circumstances, the steamer bound to keep out of the way thereby in effect says to the other: 'I can keep out of your way by going ahead of you to the left, and will do so if you do nothing to thwart me; do you assent?' A reply of two whistles, in itself, means nothing more than an assent to this course, at the risk of the



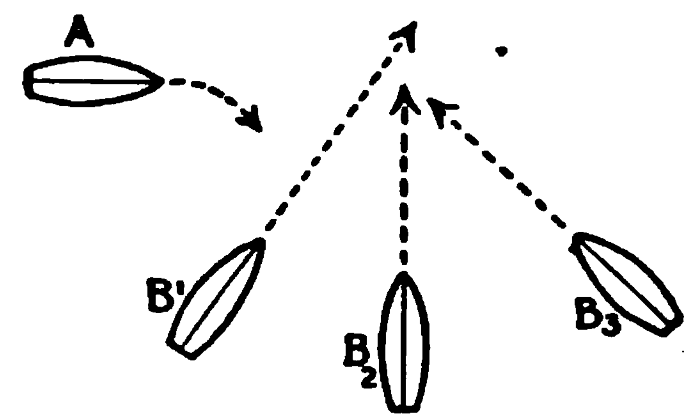
Each vessel puts helm to port and passes with her port side to the other.

Signal Exchanged: One Blast.

Exception. If necessary to pass contrary to this rule (using starboard helm) the proper signal is Two Blasts.

See Article 18, Rules Road, and "Remarks," § III, Chap. XIV.

1. VESSELS MEETING.



A keeps clear and if possible avoids passing ahead of B.

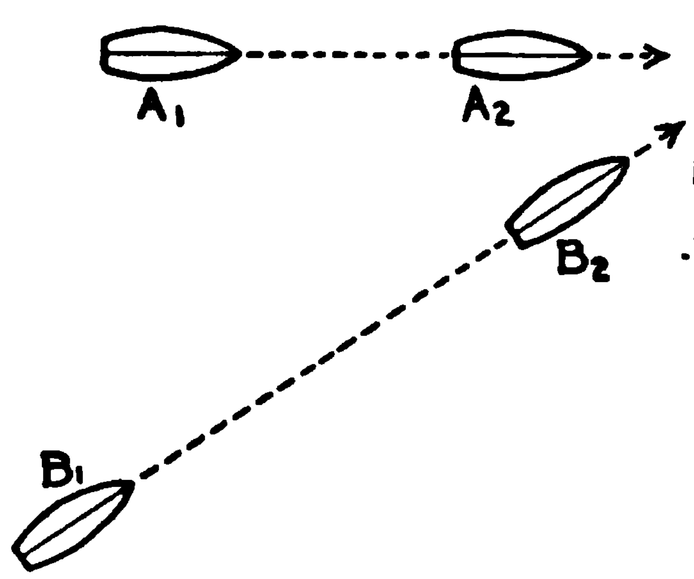
B keeps course and speed.

Signal exchanged; One Blast.

Exception.—If necessary for A to cross ahead, the proper signal is Two Blasts.

See Articles 19, 21, 22, 23. Rules Road; Pilot Rules VIII, IX; "Remarks," § III, Chap. XIV.

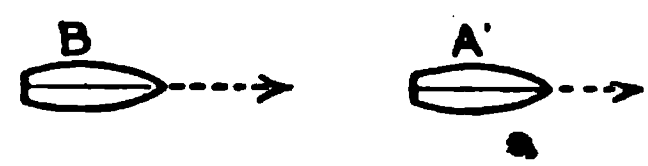
2. VESSELS CROSSING.



B has come up from more than 2 pts. abaft A's beam and must keep clear altho' she is on A's starboard hand.

See Art. 24, International and Inland Rules.

3. OVERTAKING.



If B wishes to pass A, she signals with One Blast if wishing to pass to the right, and with Two Blasts if wishing to pass to the left.

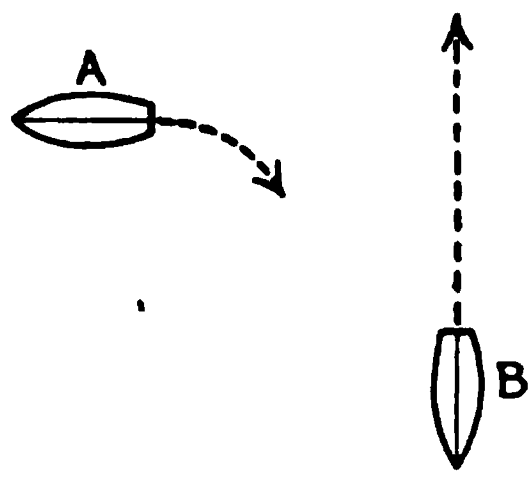
If A consents she answers with the same signal. If she does not consent, she gives several short and rapid blasts.

B must not pass until A consents.

See Pilot Rule under Art. 18, U. S. Inland Rules and Note 28 under same Article.

4. PASSING, GOING IN SAME DIRECTION.

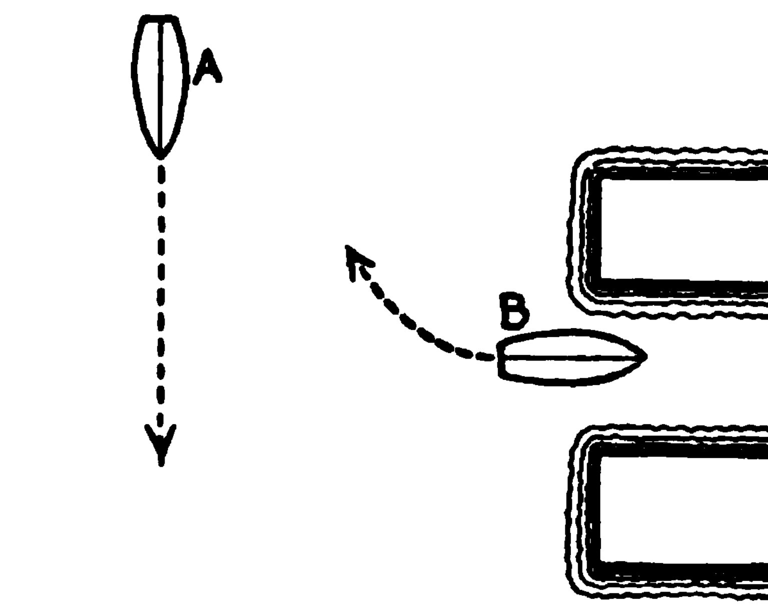
TYPICAL SITUATIONS. RULES OF THE ROAD.



Both vessels apply the crossing rule with reference to their direction of motion, so that A keeps clear of B as in Situation 2, Plate 99, and the same whistle signals are exchanged. In this case One Blast.

If it is necessary for A to back across B's line of motion, the proper signal is Two Blasts. See § III, Chap. XIV.

VESSELS CROSSING, BOTH BACKING.



The crossing rule applies as if B's stern were her bow.

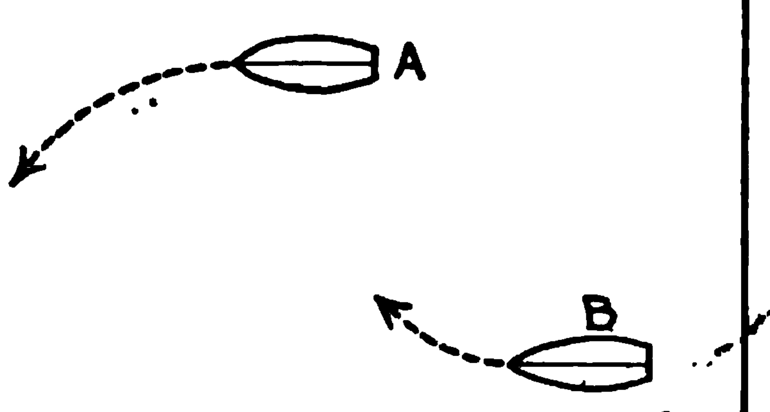
B keeps clear.

Signal in this case, One Blast

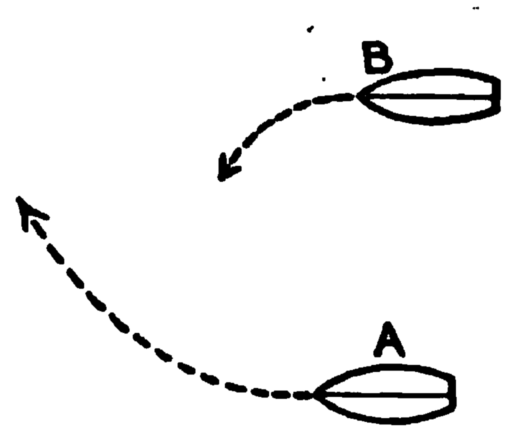
If it is necessary for B to back across A's bow, the proper signal is Two Blasts. See § III, Chap. XIV.

ONE GOING AHEAD, ONE BACKING.

-1.-



-2.-



In these situations, A being presumably faster than B, wishes to cross ahead to make her dock, or for some other reason.

As the two vessels are now on perfectly safe courses, the law does not recognise the right of A to cross, even in Situation 1, *where she has B on the port hand.*

The following manoeuvres are, however, very common in United States Inland Waters: In 1, A sounds one blast and puts her helm to starboard, B (usually) answers with one blast and takes whatever steps are necessary to keep clear.

In 2, A sounds two blasts and *waits for B to answer.* If B answers with two blasts, A puts her helm to port and crosses, and B takes whatever steps are necessary to keep clear. If, in 2, B does not answer, A (usually) does not cross.

STEAMERS ON PARALLEL COURSES. "A" WISHES TO CROSS AHEAD.

TYPICAL SITUATIONS. RULES OF THE ROAD.

vessel proposing it. Such a reply does not of itself change or modify the statutory obligation of the former to keep out of the way as before, nor does it guaranty the success of the means she has adopted to do so." "THE CITY OF HARTFORD," Federal Reporter 23, page 650.

(2) "But from the moment that such an attempt [the attempt to cross ahead] apparently involves risk of collision, both steamers are equally bound to do all they can to avoid a collision. But this general obligation applies equally whether the previous signals were of two whistles or of one. The precise acts which either is bound to do when immediate danger of collision arises must depend upon the particular circumstances, and of these circumstances the previous understanding as to the course or intention of each vessel is one of the most important. But where the circumstances are such that a course proposed by a signal of two whistles would, if assented to and adopted, require at once, as in this case, immediate and strong measures to avoid a collision, there can be no question that such a proposal is wholly unjustifiable, and a gross fault, when proposed by a steamer that is bound to keep out of the way, and is under no constraint of circumstances, but free to pursue other safe methods of doing so." The NEREUS. Federal Reporter, No. 23, page 455.

(3) "The rule of the Supervising Inspectors governing navigation in New York harbor, that a steam-vessel approaching another on a crossing course so as to endanger collision shall signify by a blast, or blasts, of the whistle what course she proposes to take can not be held to deprive the vessel which is on the starboard side of the other of her right to keep on her course as provided by Revised Statutes." The HAMILTON vs. THE JOHN KING. Federal Reporter, No. 49, page 469.

The remarks which precede with regard to crossing deal with cases in which the vessels are not hampered by any **emergency** connected with the original situation. There is another and very important case which frequently arises in crowded waters, where *A*, having *B* on her starboard hand and rather close aboard, *is obliged to cross ahead* because she has not room to manœuvre otherwise. This is distinctly an emergency situation and is covered in the International Rules by the second paragraph of Article 21, and in both the International and the Inland Rules by Articles 27 and 29. In this case the vessels exchange a two-blast signal and *A* crosses ahead, *B* taking such steps as may be necessary to let her cross safely.

Meeting Vessels. In crowded waters, it is often impracticable for meeting vessels to pass each other port to port. In such cases the practice is to exchange a two-blast signal and pass starboard to starboard. This deviation from the law is justifiable only in cases of actual necessity; yet it constantly occurs in the inland waters of the United States in cases where no possible excuse for

it exists. The custom seems to be well established among pilots, to pass on whichever side is the more convenient; and it seems to be considered that the law has been complied with if the side selected is indicated by the appropriate signal.

So well established is this custom, that its existence can not be ignored; but there is no question that it is a direct violation of the law, except, as already noted, when it is actually dictated by considerations of safety.

Vessels Backing. An interesting and important point arises when one of two crossing vessels is going astern instead of ahead. It is the practice of seamen to consider in such cases that the rules apply *with reference to the direction of motion* of the ship, so that for the time being, the starboard side becomes the port side and the port side the starboard side. This practice has been sanctioned by several decisions of the courts, and may be regarded as fully established. In other words, we must consider the pilot of a backing vessel to be facing aft, toward the direction in which his ship is moving. He must then keep clear of a vessel *on his right hand* as if that were his starboard side. And his whistle signals must correspond. Similarly, the vessel which is crossing him must regard the stern of the backing steamer as if it were the bow, etc.

Winding Channels. Where two vessels are approaching each other in adjoining reaches of a winding channel so that they are for the moment on crossing courses, it has been held by the courts that they are to be regarded as *meeting, not as crossing vessels.*

If they seem likely to meet at a bend, or in a narrow and difficult part of the channel, good judgment requires the one which is going against the current to slow until the other has cleared the difficult point and straightened out, after which there is no difficulty about passing.

This course, which is dictated by good seamanship, is in many rivers prescribed by local regulations.

Article 50 of the By-laws for the Thames reads as follows:

> *"Steam-vessels and steam-launches navigating against the stream above Richmond Lock shall ease and if necessary stop to allow vessels coming down with the stream to pass clear particularly when rounding points or sharp bends in the river."*

Similar provisions are included in the local regulations for the Trent, the Danube, and many other rivers.

The following extract from the decision in a case of collision in the Danube, where two steamers met in a dangerous part of the channel, sets forth the view which would probably be taken by the courts in similar cases, even where no local regulations existed covering the situation. It must not be forgotten, however, that this decision has to do with a case which was actually covered by a local rule:

> **"An ascending ship must stop below the passage until a descending ship has cleared it whenever the ascending ship has notice that if she proceeds she will be exposed to the risk of meeting the descending ship at or near that point; and the descending vessel must stop above the passage when the ascending ship has reached such point and has actually begun to navigate the contracted passage before notice is conveyed to her that if she proceeds she will be exposed to the risk of meeting the descending ship at or near the point.**
>
> **"When the ascending ship neglects to stop below the passage, it is the duty of the descending ship to refrain from any attempt to exercise her right of precedence, when the intention of the ascending steamer to violate the regulations becomes reasonably apparent." The CLIEVEDEN vs. The DIANA. 7. Aspinall's Maritime Cases, page 489.**

With regard to ships which for any reason pass at a bend, see remarks to Chapter XVI on rounding a bend with and against the current.

Men of War in Formation.

There are no actual decisions by the Courts of this or other countries covering the special case of a vessel encountering a fleet of warships in formation. No doubt such a vessel has all the rights accorded her by the rules of the road as regards each individual vessel of the fleet. But she would do well to remember that each vessel of the fleet has responsibilities (also under the rules of the road) toward every other vessel of the fleet and that, by entering the water of the fleet, she may create a situation of great complexity and serious danger to the ships of the fleet and to herself.

In connection, the following incident may appropriately find a place here. Some years ago (1900) the British Channel Fleet of thirty-two ships was proceeding up the English Channel in four columns abreast, when a tug and tow, standing across from starboard to port, and therefore having the right of way, held their course across, and having cleared the first (starboard) column, came into collision with the battleship *Sanspareil,* leading the second column.

It happened that the *Sanspareil* committed a fault which was perfectly evident, and she was very properly condemned for the collision, but the Court, in passing upon the case, took occasion to express the opinion that the tug and tow should never have attempted to cross ahead of the fleet or to pass through it, even though they had technically the right of way over each individual ship.

> **". . . . The ships being in that formation, it is of the utmost importance that perfect order should be preserved because to become disorganized is to run risk of great disaster. . . . . On coming up with a big fleet like that, what ought the tug and tow to have done? Consider what they proposed to do. They proposed to keep a course which would have just cleared them of the first column, which would land**

them, if the fleet did not stop, in front of the leading ship of the second column, which would carry them into the center of the third column and . . . . into about the center of the fourth column. Consider the danger cast upon the fleet by having its columns broken in such a way, the difficulty of stopping ships of that huge build and weight suddenly and interfering with their course. . . . . I do not see how, without great difficulty and danger, the Channel Fleet could possibly have done so without running great risk of injury to its vessels." From opinion of the Supreme Court of Judicature in the case of the SANSPAREIL, 9 Aspinall, Marine Cases, page 78.

§ IV. SPEED IN A FOG.

DECISIONS OF COURTS.

Extract from the decision in the case of the BOLIVIA (speed 7 to 8 knots, off Fire Island):

"The steam-ship must also be held in fault because she was not going at a moderate speed in the fog, under the special circumstances and conditions of the case. She has given no evidence to show what speed she was required to maintain in order to keep steerage-way, and none to show that at a lower rate of speed than 7 or 8 knots she would not have been under efficient control, and able to govern her own movements promptly and effectually. Under the existing state of fog, and exercising the best vigilance, she could not discover another vessel more than 300 or 400 feet away, yet maintained such a speed that, after reversing, her headway through the water could not be stopped within three times that distance.

"The locality was one frequented by numerous vessels in the coasting trade, and lay in one of the paths of the ocean traffic between Europe and the principal commercial port of this country. The steam-ship had but just passed a sister steam-ship of her own line, bound in an opposite direction; and the schooner had seen or heard several vessels during the previous half hour of the fog. Under such circumstances, it is not enough that the steam-ship moderated her speed; she should have reduced it to that moderate speed which was safe and prudent, in view of all the circumstances and conditions of the case. The rule is firmly established in this country, and also in England, that the speed of a steam-ship is not moderate, at least in localities where there is a likelihood of meeting other vessels, if it is such that she cannot reverse her engines and be brought to a stand-still within the distance at which, in the condition of the fog, she can discover another vessel."—Federal Reporter, No. 49, page 171.

From the decision in the case of the COLUMBIAN (speed 9 to 10 knots on La Have Bank):

"The only fault alleged against the steamer is excessive speed and the authorities make it clear that 9 or 10 knots an hour at any time or place is excessive speed in a fog. In saying this, I have no doubt that the captain of another steamer like the COLUMBIAN would have gone

ahead quite as fast. Had the steamer been an ocean liner instead of a freight steamer it would probably have been sent through the same fog at from 15 to 20 knots an hour, and its captain would have been blamed by his company as well as by his passengers if he had loitered along at half-speed. Though this almost universal practice may relieve the captain of a steamer from moral blame, the captain of the COLUMBIAN was none the less a transgressor of the International Rules and I am bound to find the steamer at fault. I have often had occasion to say that owners and masters must either comply with a law or secure its repeal. Experts may perhaps be found to testify that moderate speed is harmful, a fog-horn useless and a torch misleading, but the statute must be obeyed."—Federal Reporter, No. 91, page 801.

From the decision in the case of the RALEIGH:

"The rule is that such speed only is lawful or moderate speed in a fog as will permit a steamer seasonably and effectually to avoid a collision by slacking her speed or by stopping or reversing within a distance at which another can be seen. If this rule is a severe one and practically requires a steam-ship to come to a stop and remain stopped, when navigating a river having extensive commerce, or in a crowded harbor, it is too well established to be disregarded."—Federal Reporter, No. 44, page 781.

From the decision in the case of the NORMANDIE:

". . . . It is not very material whether her speed was 12 knots or 11. Either is considerably in excess of what has been adjudged in many cases in the courts of this country an excessive rate of speed in a dense fog. No doubt the question of what is moderate speed is largely a question of circumstances, having reference to the density of the fog; the place of navigation; the probable presence of other vessels likely to be met; the state of the weather as affecting the ability to hear the fog-signals of other vessels at a reasonable distance; the full speed of the ship herself, her appliances for rapid manœuvring, and the amount of her steam-power kept in reserve, as affecting her ability to stop quickly after hearing fog-signals. No doubt also that, in the absence of circumstances of special danger, navigation is not required to be suspended on the high seas on account of dense fog. Neither the rules nor the ordinary practice of seamen require that. The rules intend that signals shall be given which are expected to be heard in time to enable vessels to avoid each other, and no speed is sufficiently moderate under given conditions of wind, sea, and weather, unless it is so reduced as to enable the vessel to perform her duty to keep out of the way, from the time when she has a right to expect that the other vessel's signals, under existing conditions, will be heard.

"There is no case in the country where a speed of two-thirds the maximum speed under such circumstances as the present, has been held to be moderate speed. No doubt certain evolutions could be effected more rapidly with a speed of 10 to 12 knots than with a speed of 6. But a speed of 10 to 12 knots was not more necessary to the NORMAN-

DIE'S safe navigation in this case than was 7 knots in the case of the PENNSYLVANIA. Besides, the question is not whether certain evolutions can be executed in less time, but whether the NORMANDIE, when meeting a vessel suddenly in a fog, could as a rule, more effectively avoid her under a speed of 10 or 12 knots than under a speed of only 6 or 7."—Federal Reporter, No. 43, page 151.

* * * * * * * * * * *

With reference to the practice of the Atlantic liners in keeping up full speed in a fog, and the attempt to justify this on the ground that the time of exposure to danger is thereby lessened, the courts have held that while high-speed under these conditions may be safer for the fast steamers themselves, it is extremely dangerous to any smaller vessels which may be in their track and that it is, therefore, altogether unjustifiable.

The following decision in the case of the PATRIA is important in connection with lookouts. There are many other similar decisions:

"Besides this, I think the steamer is further to blame for not having a lookout stationed forward at the bow. Nor was the lookout doubled. There was but one seaman acting as lookout, and he was stationed on the bridge, some 75 feet or more from the bow, and was also attending to blowing the whistle once a minute. If on account of the lighter fog above, it was desirable to have a lookout as high above the deck as possible, a lookout might have been stationed in the cross-trees or crow's nest, as is often done in thick fog; but neither that, nor a lookout on the bridge, would be a justification of the omission to keep a good lookout at the bow, which it has been repeatedly held should be maintained wherever possible. The master states his opinion, that if he had had 10 seconds more time, the collision would have been avoided. Had a lookout been stationed at the bow with no divided duties, and reported the schooner at the same distance it was seen from the bridge, the steamer would have had much more than this additional time for coming to a complete stop and backing away from the schooner."—Federal Reporter, No. 92, page 411.

An exceptional situation arises when a number of men-of-war are cruising together in formation in a fog. It may reasonably be contended that a somewhat higher speed is necessary for the safe control of a squadron under these conditions than for that of a single ship, and *such speed as can be shown to be actually necessary for safety* is manifestly justified by the phrase in Art. 16, "having careful regard to the existing circumstances and conditions."

The obligation of each ship to keep clear of her neighbors in the squadron is at least as great as the obligation to keep clear of strangers, and anything which can be shown to be *necessary* for this can be justified without placing undue emphasis upon the military features of the situation.

§ V. RULES FOR VESSELS PASSING DREDGES AT WORK IN CHANNELS.

The improvement of channels in United States waters is done by the Corps of Engineers of the United States Army, and the Secretary of War is authorized to make regulations to be observed by vessels passing dredges or other craft engaged in such improvement.

EXTRACT FROM THE RIVER AND HARBOR ACT OF AUGUST 18, 1894.

SECTION 4. [As amended by Section 11 of the river and harbor Act of June 13, 1902.] That it shall be the duty of the Secretary of War to prescribe such rules and regulations for the use, administration, and navigation of any or all canals and similar works of navigation that now are, or that hereafter may be, owned, operated, or maintained by the United States as in his judgment the public necessity may require; and he is also authorized to prescribe regulations to govern the speed and movement of vessels and other water craft in any public navigable channel which has been improved under authority of Congress, whenever, in his judgment, such regulations are necessary to protect such improved channels from injury, or to prevent interference with the operations of the United States in improving navigable waters or injury to any plant that may be employed in such operations. Such rules and regulations shall be posted, in conspicuous and appropriate places, for the information of the public; and every person and every corporation which shall violate such rules and regulations shall be deemed guilty of a misdemeanor and, on conviction thereof in any district court of the United States within whose territorial jurisdiction such offense may have been committed, shall be punished by a fine not exceeding five hundred dollars, or by imprisonment (in the case of a natural person) not exceeding six months, in the discretion of the court.

Rules are drawn up for each individual situation coming under the above law, and different sets of rules may differ from each other in minor particulars, but the points covered are practically identical in all cases, and these points are illustrated in the following typical set of rules:

1. Steamers without tows passing the dredges, shall not have a speed greater than six miles an hour, and their propelling machinery shall be stopped when immediately abreast of the dredges, and while passing over the breast and quarter lines of the dredges.

Steamers with tows passing the dredges shall not have a speed greater than six miles an hour, and their propelling machinery shall be stopped while passing over the breast and quarter lines of the dredges; but they may start their propelling machinery if necessary between these lines.

2. Vessels using the channel shall pass the dredges on the side designated from the dredge by the signals prescribed in paragraph 7 of these regulations.

3. Vessels whose draft permits must keep outside of the buoys marking the ends of mooring lines of dredges.

4. Vessels must not anchor on the ranges of stakes or other marks placed for the guidance of the dredges.

5. Vessels must not run over or disturb stakes or other marks placed for the guidance of dredges.

6. Dredges and operating plant, in the prosecution of the work, must not obstruct any part of the channel unnecessarily.

7. Dredges shall display by day a black ball three (3) feet in diameter at the end of a horizontal spar extending to the line of the side of the dredge's hull, and at a height not less than thirty (30) feet above the water, the ball to be set on the side of the dredge on which it is desired approaching vessel shall pass.

> NOTE.—A red flag or other signal may be substituted for the black ball of this paragraph.

Dredges shall display by night one white light on a staff in the middle of the dredge, and at least thirty (30) feet above the water, to serve as the regulation anchor light, and four (4) red lights suspended in a vertical line from the outer end of the horizontal spar used by day for the suspension of the black ball, the lights to be set on the side of the dredge on which it is desired approaching vessels shall pass. If approaching vessels may pass on either side of the dredge, no day mark shall be displayed, and by night the four red lights shall be displayed in a vertical line directly under the abovementioned white light.

8. The breast and stern anchors of the dredges shall be marked or buoyed so as to be plainly visible to passing vessels.

9. While vessels in the channel are passing, all lines running across the channel from the dredge on the passing side must be entirely slacked.

10. Dredges will slack the lines referred to in paragraph 9 upon signal by whistle from an approaching vessel.

In addition to the authority vested in the Secretary of War to make regulations as above, the same official is empowered to regulate all other matters which have to do with possible obstructions to navigable waters; such as the dumping of ashes, garbage, etc.; the marking of wrecks and their removal; the building of bridges across navigable channels, and the handling of draws in bridges spanning such channels.

§ VI. INLAND RULES OF NATIONS OTHER THAN THE UNITED STATES.

The Inland Rules of other countries do not exist in a form which admits of convenient grouping. In most cases the rules are made locally for each port or river.

Officers having to navigate the inland waters of any country should use every effort to acquaint themselves with these local laws. In some cases they are to be found in Sailing Directions; in others they must be learned from pilots or other local authorities.

Generally speaking, it will be found that such local rules do not modify the International Rules in any important particulars. So far as they deal with the rules for vessels meeting and crossing, they frequently emphasize certain points of the International Rules; as, for example, the requirement about keeping to the right-hand side of the channel. In many cases they limit the speed which may be used within the river or harbor in question. Other matters with which they deal are the following: anchorage limits; privileges and obligations of tows; length of tows; size of rafts; lights and signals for dredges at work in the channel, and rules for passing these; special rules for vessels desiring to pass other vessels going in the same direction in a narrow channel; ferry-boats crossing the channel, or entering or leaving their slips; vessels hauling out from slips; marking of wrecks; pilotage; harbor police regulations; explosives on board vessels in the harbor; buoyage; mooring alongside docks or alongside other vessels; special rules for exceptionally narrow and dangerous parts of channel; etc.

In the case of basins enclosed by breakwaters, rules are prescribed as to the conditions for entering, permission being necessary in all such cases, and arrangements being made with the harbor master.

In the case of military ports, very stringent regulations are prescribed, and vessels visiting such ports should, if possible, inform themselves of these in advance.

As a rule, all necessary information for the guidance of a stranger can be obtained from the pilot. The rules with regard to pilots and the signals for calling them are usually to be found in the Sailing Directions.

A very full and valuable collection of local rules is to be found in "Rules of the Road at Sea," by H. Stuart Moore, published by J. D. Potter, London.

§ VII. LAWS RELATING TO THE RULES OF THE ROAD.

Penalties are prescribed for the infringement of these rules, by all nations which have adopted them as laws, and these penalties do not depend upon the question whether damage has or has not resulted from the infringement.

Where damage is done, and can be shown to be the result of neglect or violation of the rules, it is held, in the absence of proof to the contrary, to be the fault of the person having charge of the deck of the vessel offending, who will be considered guilty of a misdemeanor and punishable therefor. If death ensues, he will be subject to a charge of manslaughter.

In every case of collision, it is the duty of the person in charge of each vessel, to stay by the other and to render such assistance as may be practicable, provided he can do so without damage to his own ship, passengers and crew.

He is also required to give to the master of the other ship the name of his own ship and of the port to which she belongs, and the ports to and from which she is bound.

As soon as possible after the collision, he must cause an entry to be made in the log book, of the collision and of all facts in connection with it.

CHAPTER XV.

MANŒUVRING TO AVOID COLLISION.

§ I.

The difficulties and dangers with which this chapter has to deal are principally connected with darkness and with fog. In daylight and in clear weather, the avoidance of collisions should be simple enough. This chapter will therefore deal, first, with steamers meeting or crossing at night, and later, with the more difficult question of manœuvring in a fog.

As an aid in determining accurately the bearing of a light sighted at night, and of readily recognizing a change in this bearing, it is convenient to have installed, close to the bridge compass, a "pelorus" or dumb-compass, marked to degrees and to quarter points, accurately adjusted with its zero in the fore-and-aft line of the ship, and with a sighting-vane pivoted at the center.

It is well also to establish a clearly marked fore-and-aft line from a convenient point on each side of the bridge to some conspicuous point near the bow, by which the line on which the ship is heading may be picked up at a glance.

It must be borne in mind that turbine ships respond much less quickly to changes in engine speed than do ships having the large screws that go with reciprocating engines. Also that the power available for backing is only about one-half that of reciprocating engines.

The result is that turbine ships must rely more upon the rudder, and must be especially careful to avoid situations demanding quick and handy manœuvring.

§ II.

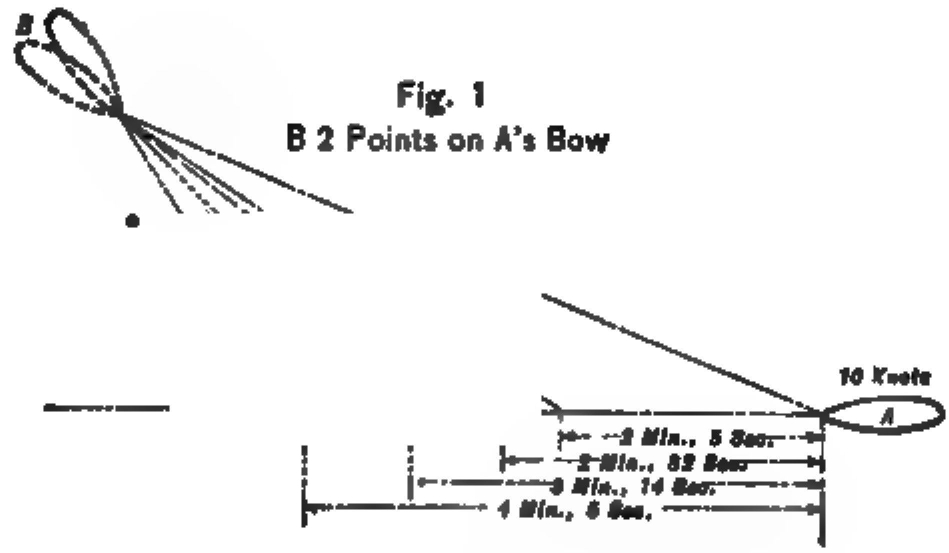
STEAMERS MEETING.

Attention has already been called to the fact that this situation is not as simple as it at first appears, for the reason that vessels which seem to be approaching each other "end-cn or nearly end-on," may in fact be crossing at a considerable angle.

There is no rule which can be laid down to eliminate the danger of such misunderstanding; but there is a certain gain in recognizing the existence of the danger and the necessity for watch-

Fig. 1

B 2 Points on A's Bow

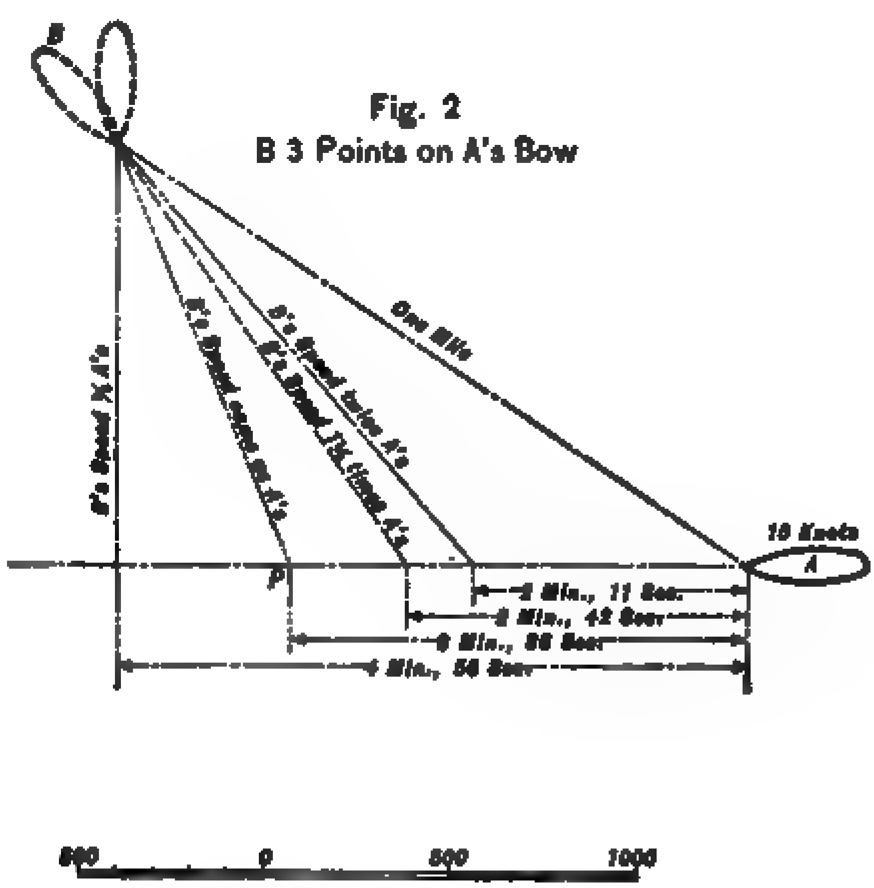


The time intervals shown assume A's speed as 10 Knots, but can be easily corrected for any other speed.

Ships are not drawn to scale.

Fig. 2

B 3 Points on A's Bow

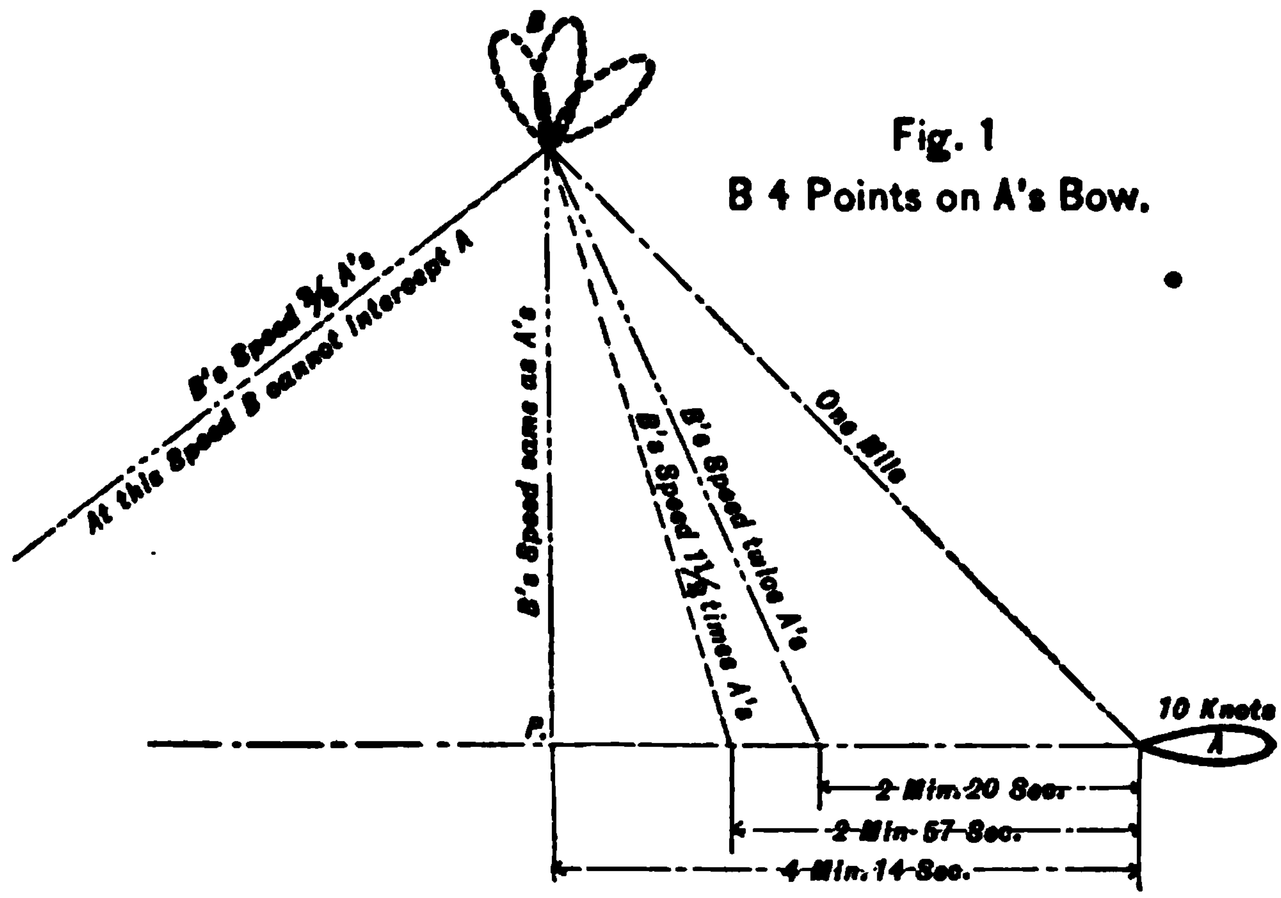


MANOEUVRING TO AVOID COLLISION.

Showing the points at which A and B will meet for various relative speeds.

Plate No. 130.

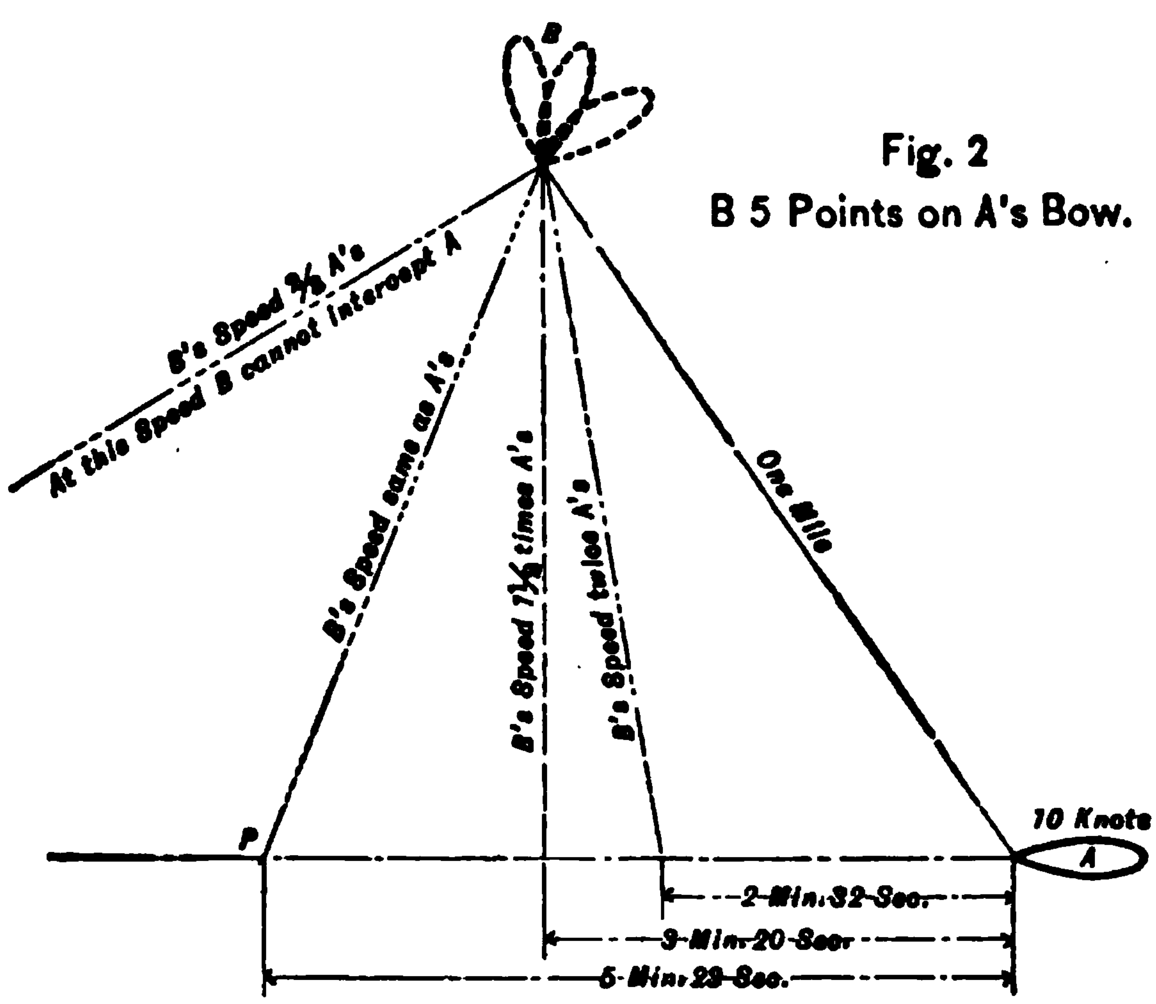
Fig. 1
B 4 Points on A's Bow.



The time intervals shown, assume A's speed as 10 knots, but can be easily corrected for any other speed.

Ships are not drawn to scale.

Fig. 2
B 5 Points on A's Bow.



Showing the points at which A and B will meet, for various relative speeds.

MANOEUVRING TO AVOID COLLISION

fulness. If the rudder is to be put to right,[1] this should be done while the ships are separated by a perfectly safe distance, and the course changed to starboard sufficiently to make sure of shutting out the green light from the view of the other ship. It is of course impossible to do this in a narrow channel, nor will it be important to do it there, as each vessel will know the course that the other must be steering; but the change of course should always be made as early as the channel permits.

When meeting another vessel in a narrow channel, there is danger in changing course too much, as to do so opens the broadside to a possible blow from the other ship. A small change made promptly, is safer than a greater change made after the ships are close aboard. On the other hand, there is the danger already pointed out, that, at night, a small change of course will not be seen by the other ship. In this situation, range-lights are especially valuable, as giving instant notice of the slightest change in the heading of a vessel seen end-on or nearly so.

In navigating crowded channels, pilots try to avoid changing course; preferring, whenever it can be done with safety, to keep clear of other vessels by reducing or increasing speed. This is less confusing than changes of course where several vessels are trying to keep clear of each other.

§ III.

STEAMERS CROSSING.

Note.—In this section, the steamer having the other on her own starboard hand is called A; *the other* B.

As preliminary to a detailed discussion of cases arising under this heading, attention is directed to the figures of Plates **129** and **130**, in which the vessels are assumed to be separated by one mile, and the courses plotted which B must be steering, for various rates of speed, in order that there shall be danger of a bow-to-bow collision with A.[2]

We do not attempt here to draw any conclusions which involve a knowledge on the part of either vessel, of the course or speed of the other.

It is apparent from these figures that, if there is to be a collision, the point at which it will take place depends upon the relative speed of the two ships. If the speeds are equal, it will be

[1] Helm to port.

[2] We cannot, of course, disregard the length of the ships; but as a basis of argument we deal here with the bows only The figures will make it clear in what way the argument must be modified to include the meeting of the bow of one ship with the stern of the other.

at P, equidistant from A and B. If B has the greater speed, the point of meeting is crowded back towards A, and the space available for A to manœuvre is reduced. If, on the other hand, B's speed is less than A's, the point of intersection recedes, and the space at A's command is correspondingly increased. It follows from this that if A is running at a low speed and finds another vessel closing in on her without change of bearing, she will know that the space at her command for manœuvring is comparatively limited, as, in all probability, the point of intersection of the courses is not far ahead.

As regards B, if it happens that she is running at very high speed, she, too, will know that in all probability the courses intersect near A and that A has probably but little space for clearing her (B's) line. It may therefore be urged that, so far as B is concerned, the obligation upon her to act for the avoidance of collision, under Art. 21 of the Rules of the Road, will increase with her speed; that is to say, if her speed is so high that A's is not likely to equal it, she will know that her course is *probably* crossing A's at a point which leaves A but little space in which to manœuvre for mutual safety.

As regards the *time* available in the cases illustrated in Plates **129** and **130**, we cannot discuss this without assuming a definite speed for A. In the figures, this is taken at 10 knots, so that B's speed becomes, for the courses laid down, 10, 15, 20 and 7 knots.

If A's speed is greater or less than 10 knots, the intervals must be changed correspondingly.

If we take the distance between the ships as greater or less than one mile, the scale of the figures must be changed.

With these speeds, we see that, when B is distant one mile and crossing without change of bearing, the bows of the two ships will meet after the intervals shown in the figures.

An important point brought out by the figures is that, if B's speed is materially less than A's, there are only certain bearings on which B can threaten collision. Suppose, for example, that B's speed is two-thirds of A's, and that she bears four points on A's bow. She cannot by any possibility reach the line of A's course in time to intercept and collide with her. As the difference in speed increases, this point comes out more and more strikingly. If A's speed is three times B's, there can be no collision if B is sighted more than 1¾ points on the bow.

It follows from this, that in the case of a steamer running at a speed so high that no vessel which is likely to cross her course can be expected to have anything like an equal speed, the danger sector is confined to a few points on either bow.

Take the case of an ocean liner, running at a speed of 20 knots, and consider her relation, for example, to sailing-vessels crossing her route. These vessels will not have more than one-third to one-half her speed. To threaten collision, then, they must bear a very little on the bow, and can be cleared, in most cases, with a few spokes of the wheel. Although this point is not usually specifically brought out, it is probably somewhat vaguely held as the basis of the contention so strongly insisted upon by the officers of the great liners, that it is safer for them to run at full speed in a fog than to slow down. This subject will be discussed in a later section, in connection with "Fog," and it will be shown that this is only one of many points to be considered in thick weather, and that the unquestionable advantage of high speed from this point of view is much more than counterbalanced by other considerations.

§ IV.

A large proportion of steamers meeting at sea approach each other on bearings from ahead to four points on the bow. It happens that this is, for reasons which will appear hereafter, the most dangerous bearing on which they can approach; and it results from this coincidence of the maximum frequency of occurrence with the maximum of danger, that something like seventy-five per cent of all collisions reported, are between vessels approaching each other on these bearings.

It will be convenient to distinguish two general classes of situations: *1st*, Those arising under ordinary conditions, where vessels sight each other at normal distances and have plenty of time and space for manœuvring to avoid collision; and *2nd*, Those in which they do not see each other until dangerously close. If any doubt exists as to whether they are dangerously close or not, it should of course be assumed that they are.

1st. Masthead lights are required by law to be visible five miles, on a clear, dark night; and this law is fairly well complied with. We shall certainly not be in error if we assume that they will show four miles, and that the side-lights of a steamer will show half as far. If bearings are taken from the time the mast-

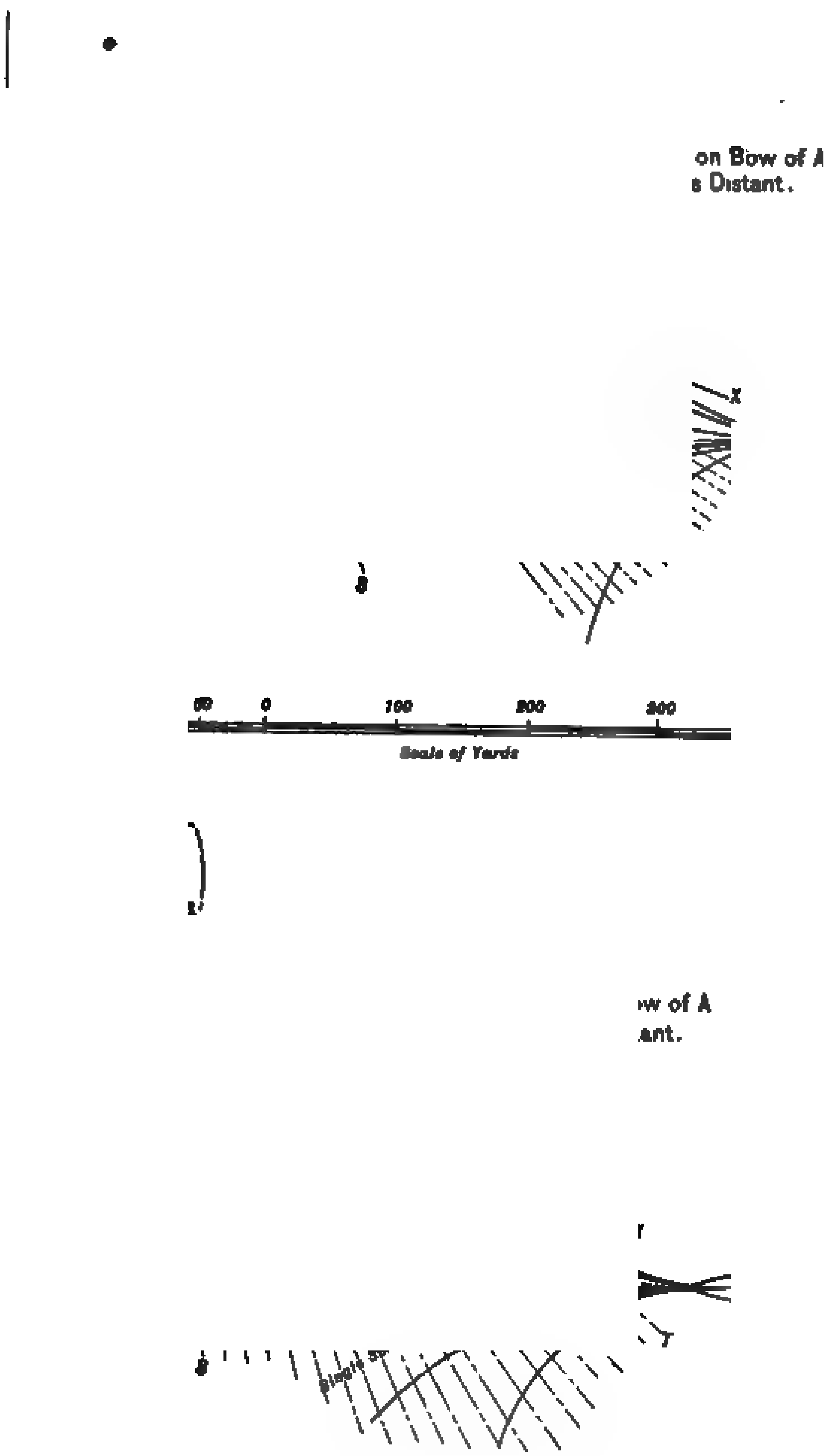
head lights are seen, the situation should be perfectly clear by the time the side-lights are made out, and if danger of collision has been found to exist, A (the "giving way" ship) should be ready to act at once. She may give way by changing speed, or course, or both, but it is always simpler to change the course than to reduce the speed materially; and this has the further advantage that it gives notice to B of what has been done—provided the course can be changed sufficiently to open the red light. It will not usually be *necessary* to make so great a change as this, merely to insure passing astern, but it is very desirable to do it if B is not too far on the bow, as it immediately clears up the situation for both ships. The whistle signal required by the Rules of the Road, for a change of course, is an additional safeguard in this case, which could not be used for a mere reduction of speed. If, however, B is more than three or four points on the bow, it will suffice to slow as much as may be necessary to let her draw ahead, changing course later if it shall seem advisable.

In changing course to avoid collision, right rudder[1] is required of A by the article which directs her, whenever possible, to pass astern of B. This is a survival of the old "Law of Port Helm" which has been the object of such violent denunciation from writers on the Rules of the Road. When confined, as it is by the present rules, to the ship having the other on her own starboard hand, this law is perfectly sound; but it was at one time regarded as applying to all ships under almost all circumstances.

2nd, If the vessels are dangerously close when they sight each other, A is relieved from the obligation to pass astern of B, unless it shall appear that this is the safest course that she can take. We shall find that, as a matter of fact, it is in a majority of cases the only course that can give her a hope of safety; and that right rudder[1] is usually even more imperatively demanded of her in this case, than when the space available for manœuvring is greater.

The first impulse of many officers in such a situation is to turn away from the danger, and at the same time to reverse the engines with full power. This course is much more likely to cause collisions than to prevent them. It may be right for B (the holding-on vessel) to turn away, if the emergency is such as to call for any action on her part; but if she does this, so far from reversing her engines, she should, if possible, increase her speed, as

[1] Port helm.



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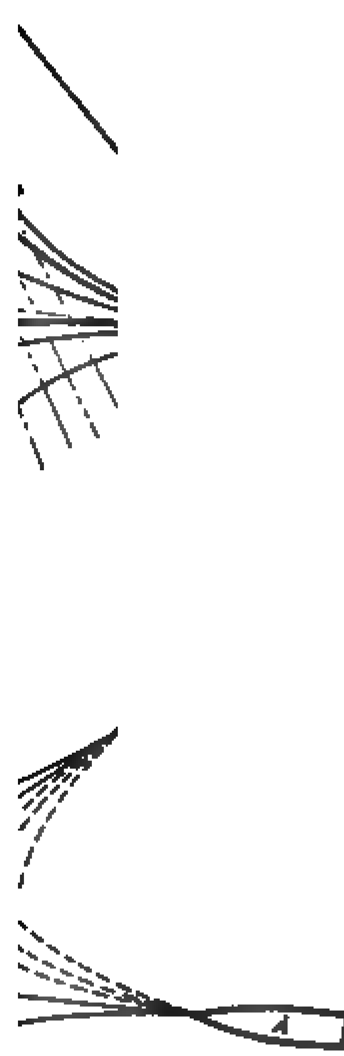

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her whole effort must be directed to getting across the bow of A as quickly as possible. On the other hand, A should reduce her speed, but should at the same time turn to starboard.

A vessel turning away from another vessel, to avoid collision should always continue at full speed, as the effort involved in this course is an attempt to cross the other vessel's bow. To turn away and slow is the surest possible way of bringing about collision.

To make it clear why A turns toward the danger instead of away from it, we may refer to Plates **131** and **132**, where B is placed, in the successive figures, on bearings from two to five points on A's bow, and showing a red light. In such a situation, the action to be taken will not depend upon the exact distance between the ships. This distance is here taken, for convenience of plotting, at 500 yards, but it may be more or less than this without modifying the principle involved, except in one special case to be hereafter considered.

As we cannot suppose that A in this case has time to watch for a change of bearing, or that she will have any information of B's course and speed beyond that given by a red and white light, we must consider that, so far as A's knowledge goes, B may be heading anywhere between the lines BX and BY. If, however, she is heading nearly along BX, she is safe to pass astern of A;[1] and if she is heading well off toward BY, the danger of collision, although it may still exist, will be comparatively remote. The situation will not be one of serious emergency unless B is heading on some course within the sector SBT.

If A turns to starboard and reverses, using helm and engines together to the best advantage, she will follow the heavy line (approximately). If she has twin screws and reverses the inner one, at the same time putting her helm aport, she will follow the light line. In either case, if she does not turn clear of the danger sector, she will cut only a few of its lines (that is to say, only a few of the possible courses of B); and she will at the same time present her stem to B, thus reducing, at once, the danger of collision and the damage to be expected if collision occurs. If she

[1] It will be noted that A could, by turning with the starboard screw backing, collide with B even if B is heading along BX; but long before this could happen, A would see B's green light and would resume her course.

turns to port, she not only cuts every one of the courses of B within the danger sector, but she throws herself across B's path broadside on, inviting the most fatal blow that one ship can give another.

If it be contended that, in placing the ships 500 yards apart, we have taken too great a distance for urgent danger, the answer is that at less than this we approach the case in which collision is not only imminent but almost inevitable and for which no hard and fast rules can be laid down. Whether, in such a case, it is safer to turn toward the danger or away from it will depend largely upon the angle at which the courses converge, and when the vessels are very close together, we may assume that something will be known about this, since it is hardly to be supposed that two vessels within a few hundred yards of each other will not see something besides each others running lights. If it is seen that the courses converge as in Fig. 3, Plate 132, the ships being very close together, it is clear that each should turn away from the other, and stop. If *A* has twin-screws she would back the port screw full speed. If she has a single right-handed screw, it may be dangerous to back if *B* is very close.

In the case where A has B nearly on the beam, the importance of turning inward is less marked than when she is on the bow, and it is generally safe to slow or stop to let her draw ahead, or at least to let the situation declare itself clearly.

With regard to B's course when she finds herself called upon under Art. 21 to act for the avoidance of collision with a vessel on her port hand (A), she should, in most cases, turn away, with right rudder,[1] and keep her speed or if possible increase it. But this involves presenting her broadside to A; and if the ships are so close that it is evident collision cannot be avoided, there is no question that B should turn inward, presenting her bow as nearly as possible to A, and stopping; remembering, if she has a single (right-handed) screw, that backing will throw her head to starboard and may defeat the object of the manœuvre. This is a situation for which it is impossible to lay down hard and fast rules; and all that is attempted here is to call attention to all the factors in the problem.

If B has twin screws, she should, if she puts her rudder to

[1] Port helm.

left,[1] reverse the inner (port) screw, and follow this up by reversing the other one as soon as she has begun to swing. There is a chance that the ships may still avoid each other, and if they meet, the damage will be less than if either of them strikes the other full on the broadside.

If A (a steamer) meets a sailing-vessel, her obligation to keep clear is the same whether the latter is on her starboard or her port hand. The law requires her, also, whenever the circumstances admit, to give way by passing astern. Where a right-handed single screw steamer is to turn to port to avoid collision with a vessel approaching from that side, it is important to remember that if the engines are reversed they will probably destroy the effect of the helm, and throw the head to starboard, thus increasing, rather than diminishing, the danger. The point is of special importance because this situation, if arising at all, is likely to come in the form of an emergency, as the lights of sailing-vessels rarely show at the distance prescribed by law, and frequently cannot be seen until close aboard. With twin-screws it is as easy to turn to one side as to the other.

It will be clear from what has been said in § II, concerning the relation of a fast steamer to a comparatively slow vessel crossing her track, that there is here a strong temptation to turn away from the slower vessel in the hope of getting across her bow; and no doubt there are situations in which this is the only thing to be done; but it is accompanied by serious risk and should be resorted to only in an extreme emergency. If it is attempted, ***the speed must be maintained at its maximum.*** In the event of turning inward, the rules laid down in § IV of Chapter XIII should be carefully observed; that is to say, in turning to port (for example) the rudder should be put hard left[1] instantly and the engines stopped; then, *after the head has begun to swing decidedly to port,* the engines should be reversed, and, finally, the rudder shifted to hard right.[2] This supposes a single right-handed screw.

§ V.

IN A FOG.

An officer hearing the fog-signal of a vessel which he cannot see, can usually form a general idea of its bearing and may be

[1] Helm starboard.

[2] Helm hard a-port.

able to judge something of its distance; but even with regard to these points, there is danger of serious error, and of all other points he is absolutely ignorant. The other vessel may be heading toward him, or crossing his course at any angle, or running parallel with him. If, however, he hears her signal more than once, he can judge whether she is drawing nearer or not, and can perhaps tell something of her course; and if she is stopped, her signal will tell him this.

A steamer's whistle can be heard, under favorable circumstances, two miles or more, and rather farther in a fog than in clear weather; but so many things affect the question of audibility that it is not safe to rely upon hearing it more than, say, half a mile, even when all conditions seem to be favorable. The fog-horn of a sailing-vessel can in some cases be heard a mile or more, but in other cases not more than a few hundred yards. The law does not require the signal (of a steamer) to be sounded oftener than once in two minutes, and in this interval, a vessel running 10 knots will cover between 600 and 700 yards, while two vessels approaching each other on a bow bearing will draw together by half a mile.

It can be shown that the safest bearing on which one vessel, A, can have the fog-signal of another vessel, B, is directly ahead. If the signal indicates that B is stopped, she can be easily avoided; and if she is standing across, she will be clear before A can reach her. There is no danger of collision, unless she is heading toward A; that is to say, within the very small angle subtended by A's beam; and in this case the vessels should be able to pass clear, after sighting each other. If they meet, it will be either stem to stem or with a glancing blow, and such collisions are never very serious.

Not only is a blow on the broadside far more dangerous than one on the stem, but the length offered by the broadside to possible collision is from eight to ten times as great as in the case of the stem; from which we may argue that, so far as other considerations of law and seamanship permit, any vessel in danger of collision with another should present her stem to the danger, rather than her broadside.

The rules governing the manœuvring of steamers, as laid down in Chapter XIII, are evidently of maximum importance in a fog,

as are also the facts in connection with stopping, given in Section VI of this chapter.

Broadly speaking, the Rules of the Road for vessels crossing apply in a fog as well as in clear weather, but a certain time must elapse, after the signals are first heard, before it can be determined whether the vessels are in fact crossing, or passing clear of each other. If they are passing clear, any change of course on the part of either may introduce danger; and no such change will be justifiable unless it can be shown to contribute, on the whole, to the *probability* of safety. In the interval of uncertainty following the first hearing of the signal (forward of the beam), the law requires that both vessels shall stop their engines. It does not require them to reverse, because this would destroy, to a great extent, the control of the ship by the helm.

Starting with this single demand of the law, we have to inquire whether anything else is demanded by seamanship.

Consider, first, the case of a steamer hearing, *on her starboard bow*, the signal of another steamer, of whose exact bearing she cannot be sure, and of whose distance she knows only that it is not great. A, Plate **133.**

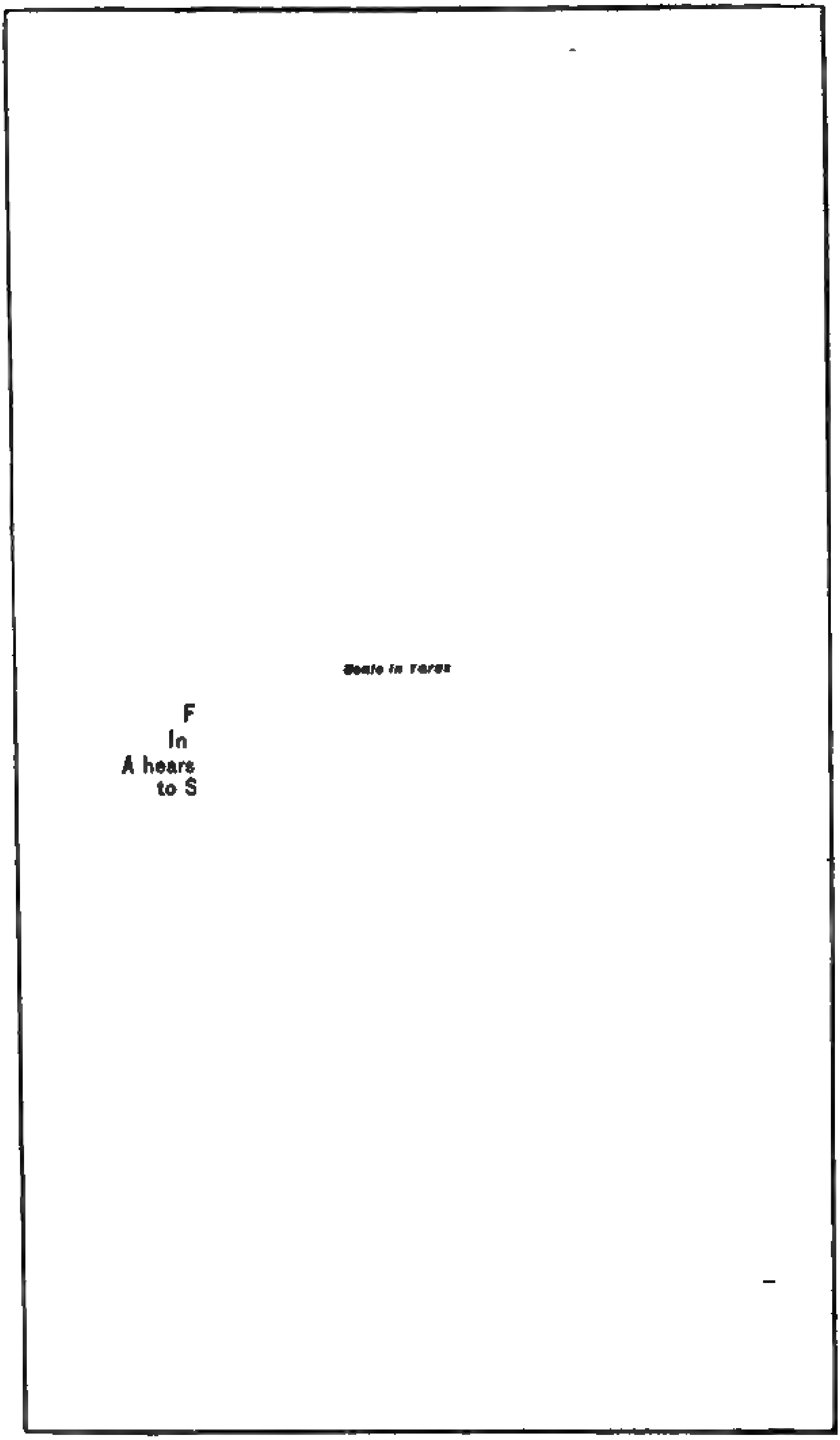
A has no means of knowing whether the vessels are crossing or not, but she knows immediately that, if they are crossing, she must keep out of the way. If she contents herself with stopping her engines, she will range ahead, with constantly diminishing speed, along the line AK. If she turns to either side, she will follow one of the curving tracks.[1] As regards the possible courses of B, we need consider only those which involve a chance of collision. These will all lie within the "danger sector" shown. Clearly, if A turns inward, she cuts comparatively few of these possible courses of B, and at the same time she presents her stem, instead of her broadside, to such danger as may exist. If time and space permit her to turn fully toward B, she will have placed herself in the safest position she could take with reference to another vessel whose course is unknown.

If, on the other hand, A keeps her course or turns away from B, she cuts directly through the danger sector, and exposes her broadside to collision in case it proves that B is heading across.

From the moment when it becomes clear that B is crossing,

[1]The tracks shown are for a vessel 300 feet long, but the conclusions drawn from them will hold for vessels of any length.

Plate No. 133.



MANOEUVRING TO AVOID COLLISION

the Rules of the Road apply to the situation; and these rules require that A shall keep clear and that she shall, if possible, pass astern of B, to do which she must turn inward; that is to say, the manœuvre required of A, *after the ships have drawn dangerously close*, is the same that is suggested by the foregoing considerations for the very beginning, when the time and space available for it are much greater, and while the ship has speed enough to be under satisfactory command.

In view of all these facts, it seems safe to say that a steamer in a fog, hearing the signal of another vessel *on her starboard bow*, should turn toward the signal in the shortest possible space and time, stopping her engines as required by law, and backing if this will assist in turning. She should not continue backing long enough to come to a dead stop unless it is evident that this is called for by the emergency. In other words, it is not well to renounce control by the helm while doubt still exists about the course and position of the other vessel. Having brought the signal ahead, she should hold the compass course thus fixed until it becomes clear what course the other vessel is making.

If the signal heard is on the starboard hand, but only a little forward of the beam, the advantages of turning immediately toward it are not so marked, although there is high authority for recommending it even in this case. It is probably better for A, after stopping her engines, to hold her course for awhile, bearing in mind, however, that if she finds reason to change her course at all it will be to starboard, and that she should be ready to do this the moment it becomes clear that B is crossing. If, later, she turns to starboard, she will probably have reason to back her engines at the same time.

We have now to consider what B should do upon hearing the signal of A, a steamer, on the *port* hand. Certain of the arguments which have been applied to the preceding case apply with equal force here, and, as far as they go, suggest that B also should turn inward (toward A); but a decisive argument against this is that, if the ships are not crossing, B is not called upon to take any action whatever; and if they are crossing, it is her duty to keep her course, letting A pass astern of her, and directing all her own efforts to getting across A's bow as quickly as possible. She should, therefore, in the period of uncertainty following the first hearing of the signal, hold her course with her engines

stopped. The moment that the situation is recognized as one of crossing, she should start her engines ahead, *unless the circumstances make it evident that she cannot get across.* In this case, which can only arise when the ships are very close, she should turn toward A and stop. Whether she should back or not will depend upon the effect this will have on her steering, and upon other circumstances as they reveal themselves at the moment.

An officer on the bridge of a steamer, hearing a sailing-vessel's fog-horn forward of the beam on either side, has several things to help him in deciding whether danger exists and how it can be avoided. The number of blasts heard will tell him on which tack the other vessel is, and the force and true direction of the wind will tell him much about her course and speed. The law requires him to stop his engines, in this as in other cases; and if the vessels seem to be meeting or crossing with danger of collision, it requires him to keep clear, and, if circumstances admit, to avoid crossing the other vessel's bow. As a fog-horn can be heard but a very short distance, it must generally be assumed in this situation that the vessels are dangerously close; and to decide whether "circumstances will admit" of passing astern of the sailing-vessel, calls for rather nice judgment; the more so as the decision must be formed without the least delay. If the steamer is running as slowly as under the law she should be, and with the large reserve of power which, as we have seen, will enable her to stop within her own length, or slightly more than this, she should usually turn toward the signal and reverse her engines (provided danger of collision is found to exist). If no danger exists, the steamer keeps course and resumes speed.

An officer in charge of the deck of a steamer should at all times, but especially at night and in a fog, have as exact a knowledge as possible of the true direction of the wind. This can be told accurately enough from the surface ripples on the water, when these can be seen. At other times, it must be estimated from the apparent direction and force of the wind and from the general direction of the sea, remembering, however, that this does not always run with the wind blowing at the time.

The wind is rarely fresh in a fog, but may blow with any force in falling snow or heavy rainstorm, either one of which is more to be dreaded than a fog.

Exception may be taken to the rules laid down above, on the ground that by turning immediately toward a fog-signal, we run a risk of introducing danger where none would otherwise exist. It should be noted, however, that this action is recommended only for the vessel which, in case there proves to be danger, must keep clear, and *and keep clear by this very manoeuvre;* also, that a vessel turning and backing at the same time, gains very little ground to the right or left of her original course, and finally that, as already noted, the best we can hope to do in a fog is to take the course which gives the greatest *probability* of safety *in view of the evidence available.*

§ VI.

SPEED IN A FOG.

This subject has been treated as a matter of Law, in connection with the Rules of the Road. It will be treated here as a matter of Seamanship.

It has been shown in § III, that a vessel running at very high speed, can, with comparative ease, avoid collision with a slow vessel crossing her path, provided that she makes out this vessel at a fair distance and is sure that it is crossing.

But in a fog, while a signal may be heard at a considerable distance, it can never be located with precision, and there is no means of telling whether the vessel from which it comes is crossing or not. The advantages of high speed are confined to cases in which the crossing vessel is actually seen; and in a fog, a vessel seen is usually so close aboard that a steamer running at full speed would strike her before helm or engines could be touched.

The claim usually put forward by the defenders of high speed is that a steamer handles better at high than at low speed. This is true enough as regards *time,* but altogether false as regards *space;*[1] and in avoiding collision, space, and not time, is the controlling factor. Time enters into the question, it is true, but in another way than this, and a way that is all in favor of low speed. *The great hope of safety in a fog lies in the sound signals prescribed by law.* These are required to be sounded once in two minutes. But in two minutes, a vessel running fifteen knots will pass over

[1] See Chapter XIII, § II, where it is shown that the space in which a vessel turns does not greatly vary with her speed.

half a mile, while two vessels approaching each other, will draw together by a mile.

As there are many conditions of the atmosphere in which signals cannot be heard a mile, it might easily happen that two vessels running at this speed would find themselves in collision without either one having heard the signal of the other. Moreover, a signal once heard gives very little information. It tells of danger, and is a command to stop the engines; but it can rarely be located, even as to the side from which it comes, until it has been repeated once or twice; and even after it is located approximately, there is certain to be some delay in acting.

At five knots, the time available for repetition of the signals, for comprehension of the situation, for decision as to the course called for, and for action upon this decision, is three times as great as at fifteen knots; and it seems hardly necessary to insist that in such an increase of time, there is an enormous increase of safety.

Closely connected with the question of speed in a fog, is that of the space in which a steamer can be stopped under various conditions. This space will depend upon the proportion of her available power which is in use for going ahead. If she is using full power, so that she has no reserve available for backing, it is found that she can be stopped in from three to five times her length; that is to say, the space required is independent of her speed, and directly proportional to her length. Thus a vessel two hundred feet long can be stopped in nine hundred feet, while one six hundred feet long may require nearly three thousand feet. For turbine ships the distance is much greater.

But a vessel in a fog, running at reduced speed, can have, and should have, a large reserve of power ready for instant use in backing, the only limitation upon this being that "blowing off" shall not be necessary. The greater the proportion which this reserve bears to the power in use for going ahead, the shorter will be the space in which she can be stopped by bringing the reserve into play; and it is evident that, at low speed, a much larger percentage of power can be held in reserve without blowing off, than would be possible at high speed. With such a reserve ready for immediate use, a steamer should be able to stop in two lengths or less; and if she turns while stopping, this distance is still further reduced. For turbine ships the distance may be doubled.

Since both the space in which a ship will stop and that in which

she will turn are directly proportional to her length, the importance of running slow and with a large reserve of power is greater in the case of a large steamer than of a small one; yet the largest steamers afloat are the very ones which habitually and openly set the law in this matter at defiance.

A reason frequently given for advocating high speed in a fog is that, the fog belt being of definite width, the danger of collision will be reduced by getting across it as quickly as possible. This is like saying that if one is called upon on a dark night to cross a public square in which people are moving about in all sorts of directions, it will be safer to run across at full speed than to walk slowly. It can easily be shown that in neither of these cases is the probability of collision reduced by reducing the time in which the danger space is crossed.

It is surprising that in none of the discussions which come up from time to time upon the subject of fog-signals, is any suggestion made as to the use of the voice. A good voice can be heard without difficulty a quarter of a mile, and by the use of a megaphone this distance can be more than doubled. It would seem that advantage might often be taken of this fact to establish communication through a fog, and to exchange information as to courses steered, speed, etc.

One of the greatest difficulties in deciding upon a course of action in a fog comes from the impossibility of determining with certainty the direction of sounds. This necessarily reduces the value of all rules which involve the location of signals heard. This difficulty is being much reduced by the development of instruments for determing the direction of sound (Submarine Signal System) and of radio signals (Radio Compass) both of which systems have been described in Chapter VIII.

It is well known that fogs do not usually extend to any great height, and that they are often thin at, and for some distance above, the surface of the water. They are probably denser at about the height of a steamer's bridge than at any other point.

By stationing lookouts as high and as low as possible, dangers may sometimes be made out above or below the fog, long before they can be seen from the deck or the bridge.

It has been repeatedly decided by the Courts that in a fog a lookout should be stationed at the bow.

It is important to remember that when vessels sight each other through a fog, the signals of Art. 28 of the Rules of the Road become available and must be used if the course is changed or the engines backed. These signals must not be used when the vessels are not in sight of each other, no matter how close they may be.

In the event of collision, it is a natural impulse for the vessel which has rammed the other, to back out as quickly as possible. This is often the worst thing that could be done, since her bow must be for the moment closing more or less perfectly the hole that it has made. Often, by keeping the engines of the ramming ship at dead slow ahead, it will be possible to save the other ship from filling and sinking long enough for the passengers and crew to make their escape—perhaps directly to the deck of the ramming ship.

As to the duties of both ships under the law, see § VII of Chapter XIV.

Collision mats (Plate **134**), supplied to all men-of-war, are rectangular mats made of two or more thicknesses of canvas, quilted together, and fitted with lines from the corners, for getting the mat into position over the side wherever it may be needed, and holding it there. This calls for "*hogging lines,*" leading from the lower corners under the keel and up on the opposite side, and others leading up to the rail on the side where the mat is placed; also for "*distance lines*" from the corners to stretch the mat forward and aft. To get the hogging lines under the keel, they must be dipped over the stem and passed aft to the point where they are needed. It was at one time the custom in the navy to carry hogging lines under the keel at all times, but this was found to chafe the lines and to rub off the paint. It is now prohibited.

Hogging and distance lines are usually of chain or wire or both, and are always galvanized.

A collision mat properly placed may be a great help to a ship which is dead in the water, but its usefulness is greatly reduced if she attempts to steam at any speed. Its principal value is to make other repairs possible—usually from the inside of the ship; though, of course, if any sort of structure is to be used on the outside, the mat may be kept in place *under* this and may thus continue to be efficient.

It might, for example, be practicable to construct a screen of planks to be hauled down over the outside of the mat and bound in place by lines around the ship and under the keel. If the hole is near the turn of the bilge, the planks might be seized together by short turns of rope passing through holes near the edges of the planks, these turns acting as hinges and making the screen sufficiently flexible to accommodate itself to the shape of the hull. A large piece of canvas—perhaps an awning—might be put on outside of all, and held in place by still other lines passed under the keel.

Having, by methods of this kind, checked the rush of water, it will usually be possible to build up a structure inside the ship which can be braced and caulked in such a way as to admit of proceeding to port.

If a water-tight compartment is to remain flooded, its bulkheads must be very securely braced from adjoining compartments.

CHAPTER XVI.

PILOTING.

§ 1.

The navigation of a ship at a distance from land, sometimes known as "Proper Piloting" is not a matter of Seamanship. This chapter will therefore deal only with the handling of vessels in coasting and in navigating harbors and other restricted waters by the aid of soundings, buoys, lights, ranges, etc. For safe navigation under these conditions, it is important that the compass[1] error should be accurately known, that reliable soundings should be had at frequent intervals, and that facilities should be provided for taking bearings quickly and plotting them accurately. The Gyro compass, with its repeaters, is replacing the magnetic compass and pelorus.

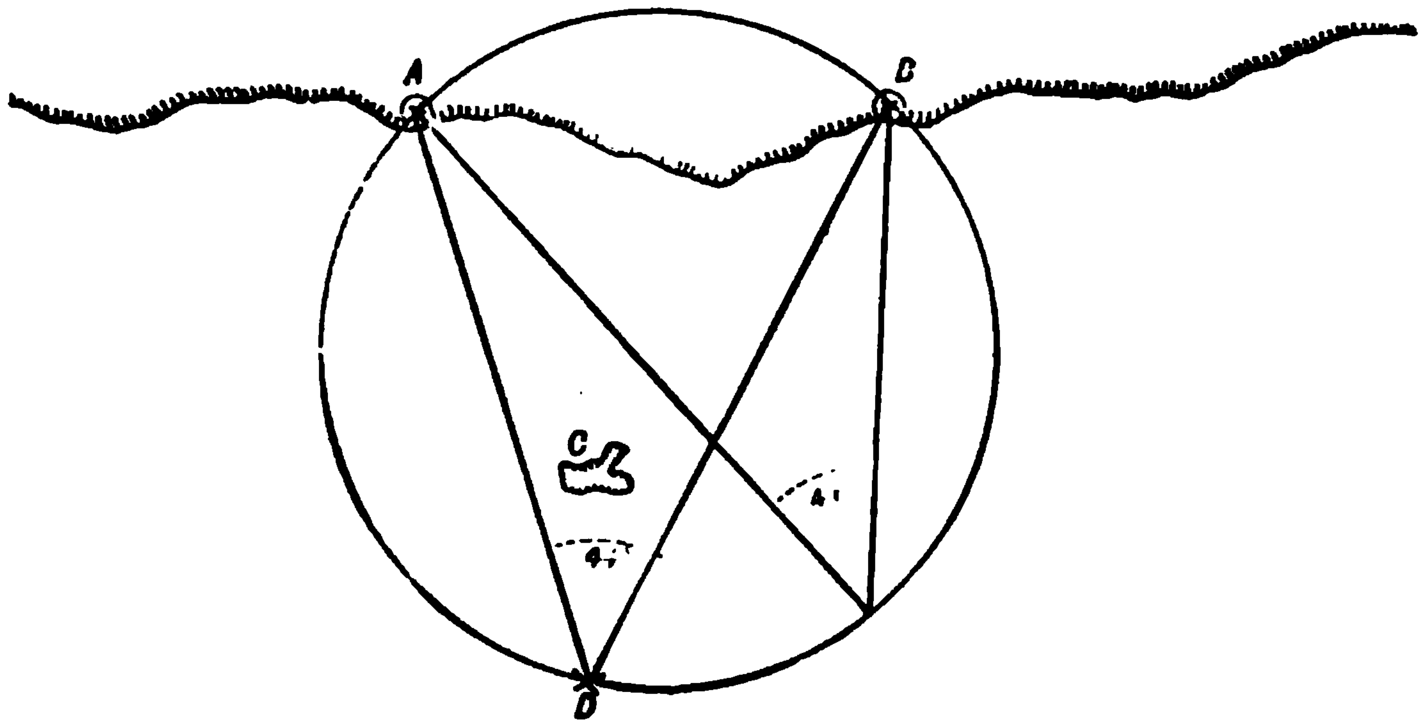
The compass error should be determined for the courses that are to be used in coming upon the coast, at the latest possible time. The leadlines should be examined and their marks verified.

Good leadsmen are rare and time and trouble are well spent in training a few of them who can be relied upon when exact results are needed.

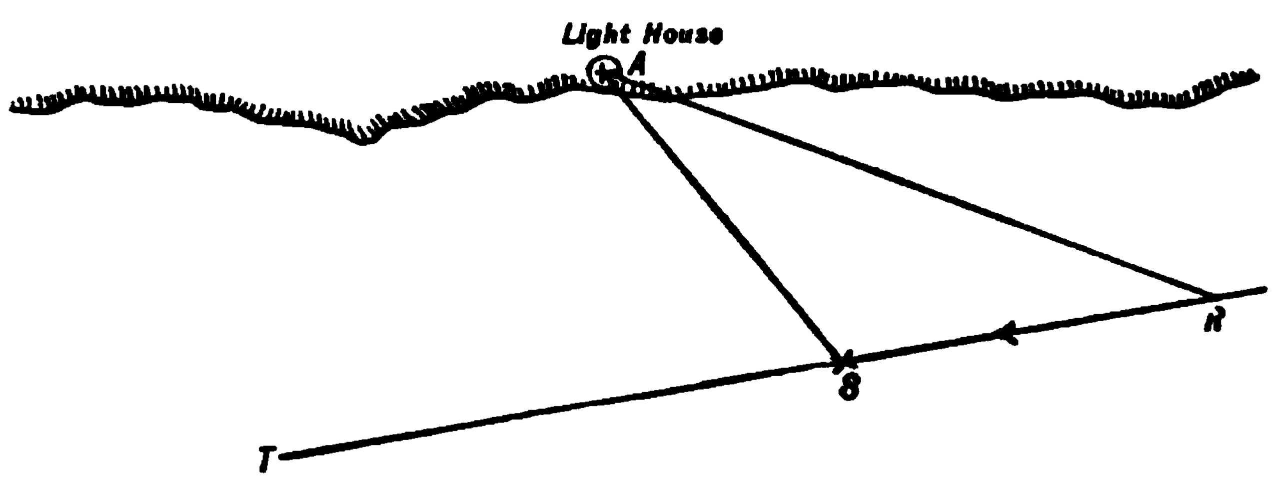
The Charts, Sailing Directions, Light and Buoy Lists, etc., should be studied and care taken that they are corrected to date.

It is very desirable that the chart should be habitually kept on the bridge in pilot waters and for this it is convenient not only to have a large board permanently fixed on the bridge, but to use, in addition to this, one or more smaller portable boards to which the charts are tacked and which can be moved about at will. The use of two of these portable boards does away with the necessity of ever handling a loose chart on the bridge, as each chart can be tacked to its board in the chart-house and kept there until wanted. The portable board also does away with the necessity for going to the fixed board whenever it is desired to refer to the chart—a point which may be of great importance in a crowded channel.

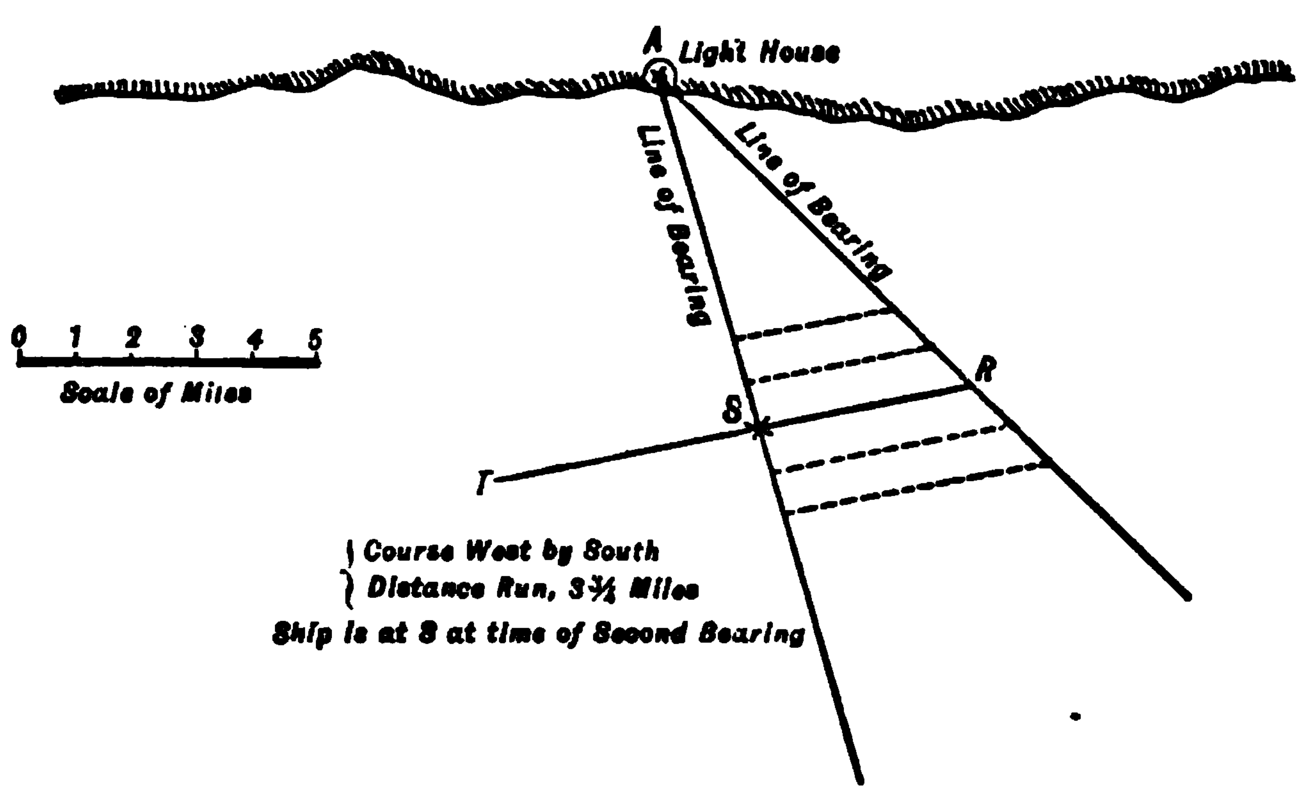
[1] Magnetic compass.



Horizontal Danger Angle.
Fig. 1



Determining the Position by Two Bearings with the Run between.
Fig. 2



Fixing the Position Graphically by Two Bearings with the Run between.
Fig. 3

DETERMINING POSITION IN COASTING.

For taking bearings, the compass, magnetic or gyro,—fitted with a proper azimuth circle—is the most convenient instrument that can be used. When it is not available, the pelorus is substituted for it. (See chapter on "Compass, Log and Lead.")

Sextant angles are sometimes to be preferred to compass bearings, but are not as universally available. They are unquestionably more reliable than compass bearings where everything is favorable for their use, if only because they involve no such uncertain element as deviation; but they require three conspicuous and accurately charted objects separated by favorable angles; and these conditions are not always to be found. All officers should, however, be familar with the use of the sextant for measuring horizontal angles and of the three-arm protractor for plotting them.

Another convenient and valuable use of the sextant in piloting is for determining distances by the vertical angles subended by light-houses, etc., the heights of which are known.

Tables are published which give at a glance the distance of an object of a certain height corresponding to any observed sextant angle; but in the absence of such a table, it is not difficult to make the necessary calculation. A common application of this principle is the "vertical danger-angle." Having to pass a light-house or some similar object of known height, we decide at what minimum distance it shall be passed, determine the angle which it will subtend at that distance, and then, by frequent observation, make certain that the angle is not allowed to exceed this value.

Strictly speaking, the height of the observer's eye is a factor in this problem, but for ordinary purposes this may be disregarded.

Evidently the same angle enables us to keep at a safe distance *inside* of an outlying danger if we have to pass between it and the coast;and we may even work our way between two dangers in this manner.

The "Horizontal Danger-Angle" is used where there are two well-defined objects in the vicinity of a hidden danger. In Fig. 1, Plate 135, suppose A and B to represent two promi-

[1] See the Chapter in Lecky's Wrinkles in Practical Navigation, on "The Station Pointer"—this being the English name for the three-arm protractor.

nent objects which are plotted on the chart, and C an outlying danger. At a safe distance to seaward of C, place a mark D, and draw a circle through A, B and D. Draw also the lines A D and B D and with a protractor measure the angle A D B. This angle is the "danger-angle." So long as the angle between A and B measured at the ship is less than A D B, the ship is outside the circle shown. If the angle becomes greater than A D B, she is within the circle. When it is equal to A D B, she is on the circle.

It is a well-known geometrical proposition that "all the angles inscribed in the same segment of a circle are equal." In other words, all the angles that can be formed by lines drawn from points in the circumference to the extremities of the chord A B will be equal to each other. As we pass inside the circle, the angles will increase; as we pass outside they will decrease.

In running along the land with prominent marks in sight, the position should be plotted frequently, as there is always danger that the ship will be set in by a current of which the chart and Sailing Directions give no hint. If two well-marked points are in sight, so placed that their lines of bearing "cut" at a favorable angle, the simplest method of fixing the position is by cross-bearings. If only one suitable object can be seen, its line of bearing may be plotted and an attempt made to fix the position of the ship on this line by an estimate of distance, by a sounding or by some other means. If the object seen chances to be a light just coming above the horizon (a common situation), its distance may be determined with considerable accuracy from its height and that of the observer's eye. It happens that the distance from any given height to the visible sea-horizon is, in miles, approximately equal to the square root of the height in feet. Thus, if an observer whose eye is 25 feet above the water-line, sees, *just on the horizon*, a light whose height he knows to be 100 feet, he will not be far wrong in assuming its distance as 15 miles.

For more exact results, the following table is convenient:

TABLE OF DISTANCES AT WHICH OBJECTS CAN BE SEEN AT SEA, ACCORDING TO THEIR RESPECTIVE ELEVATIONS AND THE ELEVATION OF THE EYE OF THE OBSERVER.

Heights in feet.	Distances in nautical miles.	Heights in feet.	Distances in nautical miles.	Heights in feet.	Distances in nautical miles.
5	2·565	70	9·598	250	18·14
10	3·628	75	9·935	300	19·87
15	4·448	[illegible]	10·26	350	21·[illegible]
20	5·130	85	10·57	400	22·94
25	5·736	[illegible]	10·88	450	24·33
30	6·283	[illegible]	11·18	500	25·65
35	6·787	100	11·47	550	26·90
40	7·[illegible]	110	12·03	[illegible]	28·10
45	7·696	[illegible]	12·56	[illegible]	29·25
50	8·112	130	13 08	[illegible]	30·28
55	8·509	140	13·57	[illegible]	32·[illegible]
60	8·886	150	14·22	900	[illegible]·54
65	9·249	200	16·22	1000	36·28

Example.—A tower, 200 feet high, will be visible to an observer whose eye is elevated 15 feet above the water, 21 nautical miles nearly: thus from the table:

15 feet elevation,	distance	visible	4·44	nautical miles.
200	"	"	16·22	"
			20·66	

Abnormal refraction may introduce an error here. And on a coast where the rise and fall of the tide are excessive, neglect to allow for this might be a serious matter.

If the light is *above* the horizon, the observer may move downward until he finds the height that brings it to the water-line.

Two observations of a single object will give a "fix," if the course and distance run in the elapsed time are noted. In running on a steady course with such an object in sight we have a series of simple triangles formed by the intersection of the course with the successive lines of bearing (Fig. 2, Plate 135). In these triangles, we have given the side R S, representing the distance run between any two bearings, and the angles made by these bearings with the course; A R T and A S T. The triangles might, of course, be solved simply enough by ordinary mathematical processes, but these are not suited for work on the bridge. The table which follows gives the solution without calculation. It is a good plan to have a copy of this posted on a board and hung in the chart-house.

TO FIND THE DISTANCE OF AN OBJECT BY TWO BEARINGS, KNOWING THE DISTANCE RUN BETWEEN THEM.

Rule.—Under the number of points contained between the course and second bearing, and opposite to the difference between the course and first bearing, will be found a number which multiplied by the miles made good will give the distance of the object (in miles) at the time the last bearing was taken.

N. B.—Due allowance should be made for current.

Difference between the Course and Second Bearing in Points of the Compass.

Example.—A lighthouse bore WNW. The ship ran 6 knots, West, and the lighthouse then bore NW. ¾N. Required the distance of the lighthouse at the time of the second bearing.

Angle between the course and first bearing = 2 points.
" " " " " second " = 4¾ "
Multiplier from table = 0·81
Distance = 6 × 0·81 = 4·86 nautical miles.

In the absence of a table, the problem may be solved graphically by plotting the lines of bearing on the chart and determining by the aid of rulers and dividers where the *given course* must cut these lines to make the distance between them equal the run of the ship (Fig. 3, Plate 135).

There are several convenient applications of the above-described principles to practical cases, which call for neither a Table nor a Chart. If the second observation is taken when the angle between the line of bearing and the course (A S T) is exactly double what it was at the time of the first observation

(A R T), the distance of the ship from the object at the time of the second observation is equal to the run of the ship between the observations.

Again, knowing the distance A S, and the angle A S T, we may by reference to the Traverse Table, determine the distance at which the point A will be when abeam.

It will be understood that in all observations involving the run of the ship, allowance must be made for any current that may be known to exist.

If the first bearing is taken when the point A is exactly on the bow and the second when it is abeam, the distance at the time of the second observation will be equal to the run of the ship between observations. This method of fixing the distance from an object when abeam is called the method of "Bow and Beam Bearings" and is usually carried out with all prominent landmarks passed. There is no reason why both this method and the preceding one should not be made matters of routine and all observations connected with them entered in a "Coasting Record" to be kept in the chart-house.

In this connection, attention may be called to the importance of recording all observations accurately at the time they are made, and of noting the reading of the patent log for every observation that has to do with the navigation of the ship, whether this be a sight, a sounding or a bearing.

Advantage should be taken of every opportunity for getting a line of position by means of two objects "in range" with each other. This calls for no measuring of bearings and is at once the most convenient and the most accurate line that can be obtained. If, at the instant that the range is closed, a bearing of another object be noted, or the sextant angle measured between another object and the range, the position is fixed at once.

A convenient way of determining the compass-error for the compass-heading at the instant is to take the bearing of a well defined and accurately charted range.

As a general rule, where coasts are well charted, well lighted and well buoyed, the safest way to navigate them is to keep close enough to see and clearly identify the landmarks in regular succession, running from one mark to another with careful bearings on them all, taking advantage of every opportunity

to fix the position, and watching especially to see if the ship is being set in toward danger as she often will be by currents which, in many cases, there is no reason to anticipate. In this way, the position is always known within a few miles and it is much safer than to keep off so far that marks cannot be seen, until the time when it becomes necessary to close with the coast; for when this time comes, you may be far out of your reckoning and a little mistake in standing in may have serious results. Another reason for keeping hold of the marks is that if the weather becomes thick, you know your position with certainty up to the last moment and so have a "departure" upon which you can rely for running in the fog. It is needless to say that in a fog, dangers should be given a wider berth than in clear weather, but even in a fog it is safer to feel the way along by careful soundings and by the help of the sound signals provided for the purpose than to cut adrift from everything. (See Section III of this Chapter.)

On coasts which are not well surveyed, no chances should be taken.

It must be remembered that buoys are often out of place and that light vessels may be so; and every effort should be made to fix the position by means of permanent landmarks. Even when buoys, etc., are changed intentionally and with due notice, it may happen that the notice is not received. A vessel approaching New York some years ago at the end of a passage from the Pacific went aground in thick weather because Sandy Hook light-vessel had been moved (three months before) and notice of the change had not been received.

In approaching a harbor, it is important to know not only the state of the tide as to height, but the direction and force of the tidal currents that may be expected. (See Section II.) After the channel is actually entered, the direction of the current may be known from its effect upon buoys and upon vessels at anchor, and all indications of this kind should be carefully noted. It will rarely happen that the currents run perfectly true to the direction of the channel; and where they draw across, the ship will be set over to one side unless a proper allowance is made by heading a little higher than the course that is to be made. In cases of this kind it is very helpful to use a *range;* and if none is laid down on the chart an effort should be made

to pick one out ahead. The objects seen need not be recognized to be of use for this.

The line on which the ship is running should be laid down on the chart and the position plotted frequently by such means as are available. This will give warning if she sags to either side.

A ship handles better with the tide against her than when running with it. If obliged to come in with a fair tide, the speed should be kept as high as circumstances permit, to insure good control by the rudder. An exception to this rule exists when a sharp turn is to be made, as hereafter explained and as illustrated in Plate 136.

In approaching a strange harbor, there may be difficulty in recognizing the landmarks and aids to navigation as laid down on the chart. Under such circumstances the ship should be stopped, and if necessary anchored, until the situation is made out clearly. If in doubt about the reliability of surveys, or if the channel is not buoyed, it is well to send a boat ahead to sound it out and mark it temporarily. In running among coral reefs, danger may be made out from aloft at a considerable distance, and intricate passages may be threaded in this way in perfect safety, *provided the sun is at the back of the observer.*

On a coast where careful soundings have been made and charted, the sounding machine gives a valuable means of locating the position. This will be described in another section upon " Navigating in a Fog."

§ II. CURRENTS.

Perhaps the most serious danger connected with piloting is that arising from currents, the force and direction of which are not known. This danger is greater in a fog than under other circumstances, but is one that should be kept in mind at all times when navigating in the neighborhood of dangers.

In most cases there is no way of foretelling with certainty the direction and force of the current to be anticipated at a given place and time, but this ought not to be true of such currents as are *tidal* in their nature. These are closely connected with high and low water; but whereas very elaborate tables are published giving the time of high and low for all parts of the world, there is so little information published with regard to tidal currents that many of the people to whom such information would be of value, remain, after years of sea-faring, under the impression

that "slack" water corresponds to "high" and "low," that a falling tide is necessarily accompanied by a current running out, and a rising tide by one running in.

This is so far from being true that at many places high and low water correspond with the maximum strength of tidal current. This commonly occurs where a large basin is to be filled through a relatively narrow mouth, as in the case of Chesapeake Bay, and where a narrow body of water lies open to the sea at both ends, as in the English Channel.

"We must take care not to confound the time of the *turn of the tide stream* with the time of high water. Mistakes and errors have often been produced in tide observations by supposing that the turn of the tide stream is the time of high water. But this is not so. The turn of the stream generally takes place at a different time from high water, except at the head of a bay or creek. The stream of flood commonly runs for some time, often for hours, after the time of high water. In the same way, the stream of ebb runs for some time after low water.

"The time at which the stream turns is often different at different distances from the shore; but the time of high water is not necessarily different at these points.

"In the center of all open channels when the tide runs right through, the streams nearly invariably overrun the times of high and low water by about three hours. In such a locality the stream due to the flood will commence three hours before high water and continue to run for three hours after high water, in the same direction.

"In tidal rivers a modified form of the same phenomenon occurs, *i. e.*, the stream runs up for some time after the water has begun to fall, and runs down after the water has begun to rise."

"Near the sides of a channel of any width, and whose sides are shallow, the direction of the tidal stream is rotatory. On the left hand, looking up the channel with the flood stream, the direction of rotation is with the hands of a watch; and on the right-hand side, in the contrary direction in the following manner: At low water, the stream will be running down the channel; at half tide, it will be flowing toward the shore; and at half ebb, it will be ebbing directly away from the shore. In the upper parts of estuaries or tidal rivers, where shallow water prevails, the duration of the flood stream is commonly shorter than that of the ebb. The higher up the estuaries, the greater will this difference become. This is apparently due to the retardation of the advancing tide caused by friction over the shoals, and when the range of tide is great, the water becomes heaped in the lower part of the estuary, finally rushing up the higher part in a wave, which, in extreme instances, has a more or less vertical face and is called a "bore." The Yangtse, Amazon and Seine are cases in point. In such a case, the tide rises perhaps half its height in a few minutes and the whole duration of flood stream will be confined to two or three hours or even less, the remainder of the twelve hours being occupied by the downward or ebb stream." Whewell, "Treatise on Tides."

It is only on an open coast line or in a shallow basin that slack water corresponds with high and low.

In a basin like Chesapeake Bay, the wave of high water travels up until it reaches and is reflected back from the head of the bay. There results from this a rather complicated condition of affairs in the bay, with two points of high and two of low, water, with points of slack midway between the adjoining high and low.

In a place like the English Channel, which lies open to the tides at both ends, the currents flow from both sides toward and away from a certain point, which in the case of the English Channel is near Dover. In this case, moreover, *the tide turns throughout the whole length of the channel at practically the same moment.* Similar phenomena occur in Long Island Sound and East River, which constitute together a single body of water open to the tide at both ends. Here the tidal currents meet and separate at Throg's Neck. It is slack water at practically the same time along nearly the whole length of the Sound, and the same is true of East River, where it is slack at, approximately, one hour and twenty minutes after high and low at Governor's Island, the current running from both sides toward Throg's Neck for six hours preceding slack water high, and *from* the same point for the six hours between slack water high and slack water low.

Local conditions may greatly modify the rules as laid down above. The currents are always weaker near shore than in the middle of the channel, and often run in the opposite direction, sometimes with considerable force. A striking illustration of this is to be seen in Wallabout Bay, an offset from the East River (New York harbor) on which the New York Navy Yard has its water front. At the strength of the flood tide, when the current in the river is running up (to the northeast) with a velocity of several knots an hour, a strong counter current runs along the face of the "Cob-dock" at the Navy Yard. Between the two currents an eddy is formed, which, as the currents slack, flattens out, growing longer and narrower, and finally disappearing as slack water is approached. There is no corresponding phenomenon while the ebb current is running, although the contour of the river results in some puzzling irregularities in the direction of the current.

As has been pointed out in the extract from Whewell quoted above, tidal currents do not always run in and out along the same line, but in many places swing through a complete circle, running, at different stages of the tide, from every point of the compass. This is well illustrated at Charleston Entrance, South Carolina. Here the first of the flood runs to the southwest, the middle of the flood to west, and so on until it has worked around to a little east of north, at which point the flood ends. A little later the ebb current begins, running to northeast, turns to east by the middle of the ebb, and so works around to south, where it ends. Other very striking illustrations occur at various points in the neighborhood of the British Islands, and the adjoining coasts of Continental Europe, where the currents are strong and often apparently erratic.

In so far as the currents of the British Islands are tidal in character, they have been very carefully studied, and the results are given in the "Tide Tables for British and Irish Ports," published by the Hydrographic Department of the British Admiralty.

Similar, though less complete, information for United States waters is published in the Tide Tables issued by the Coast and Geodetic Survey. All of this information should be familiar to officers having occasion to navigate the waters in question.

By far the most dangerous currents with which the navigator has to deal are those which, whether tidal or not in their origin, are encountered beyond the limits where tidal currents are usually looked for.

Opposite the mouth of a large basin like Delaware or Chesapeake Bay, the tidal current setting in or out is often felt many miles to seaward, and vessels in the neighborhood of such basins should be very watchful. Vessels passing twenty miles outside of the Delaware Capes have been set in toward the shoals by as much as three knots an hour, and there can be no doubt that this phenomenon accounts for many of the wrecks which occur every year along the coast of New Jersey, most of which occur where vessels are standing to the northward in thick weather.

In places where long shoals extend far out from land, there is almost always a current setting across. For reasons which are not clear, such a current almost invariably cuts in at more or less of an angle *toward the coast.* This has been frequently noted on

Lookout and Frying Pan Shoals, off the coast of North Carolina, which are the scenes of frequent wrecks.

Where a long stretch of straight coast, like that from Hatteras northward to Cape Henry, would seem to preclude the probability of a current, there is often a very marked set, chiefly up or down, but always with a more or less pronounced tendency toward the coast.

These phenomena are the more dangerous because due to causes which are too obscure to be identified; being probably connected in some cases with gales or with long continued winds from a certain quarter, which have, perhaps, ceased to blow; or to winds prevailing farther to seaward and causing a general set toward the coast. The important point is that the navigator should always be prepared to find a current setting him in some direction whenever he is near a coast of any considerable extent, even though his Sailing Directions give no hint of such danger, and no reason for it is apparent.

Even when everything points to a current from a certain direction, there are many chances that it will be found running in some other direction. The Gulf Stream northwest of Cuba and in the Florida Straits—perhaps the most strongly marked ocean current in the world—is occasionally found running directly *across* the axis of the straits; and sometimes after a prolonged "Norther" may be found running south and west toward the Yucatan Channel and the Caribbean Sea.

It has been stated in § I that a vessel handles better when running against a current than when running with it. To this there is one exception. Where a sharp turn has to be made, the ship will make it better on a fair tide—in fact, it is dangerous to attempt such a turn against a strong head tide. This will be clear from Plate 136. In Figs. 1 and 2, a long steamer is shown attempting to round a turn against the current. As her bow reaches out beyond the point, it is caught by the current on the wrong side, and swept off the wrong way, giving her a rank sheer across (Fig. 1). A moment later her stern feels the back water sweeping out from the far side of the bend, and tending to cut her stern around the wrong way. Thus there are two forces at work, one on the bow and the other on the stern, to keep her from making the turn. In Figs. 3 and 4 are shown the corresponding forces when the tide is fair. Here everything favors the turn, and it is difficult to keep the ship from coming around.

Plate No. 136.

Fig. 1.

Fig. 3.

Some years ago, a large schooner anchored in the Piscataqua River below Henderson's Point, parted her cable in the middle of the night and went up the river with a five-knot current. At that time the river made a narrow right-angle bend around the Point, and the turn was regarded as difficult enough under the most favorable conditions. The schooner, with all hands on board asleep, rounded the point without touching, and brought up on a shoal a mile and a half further up the river.

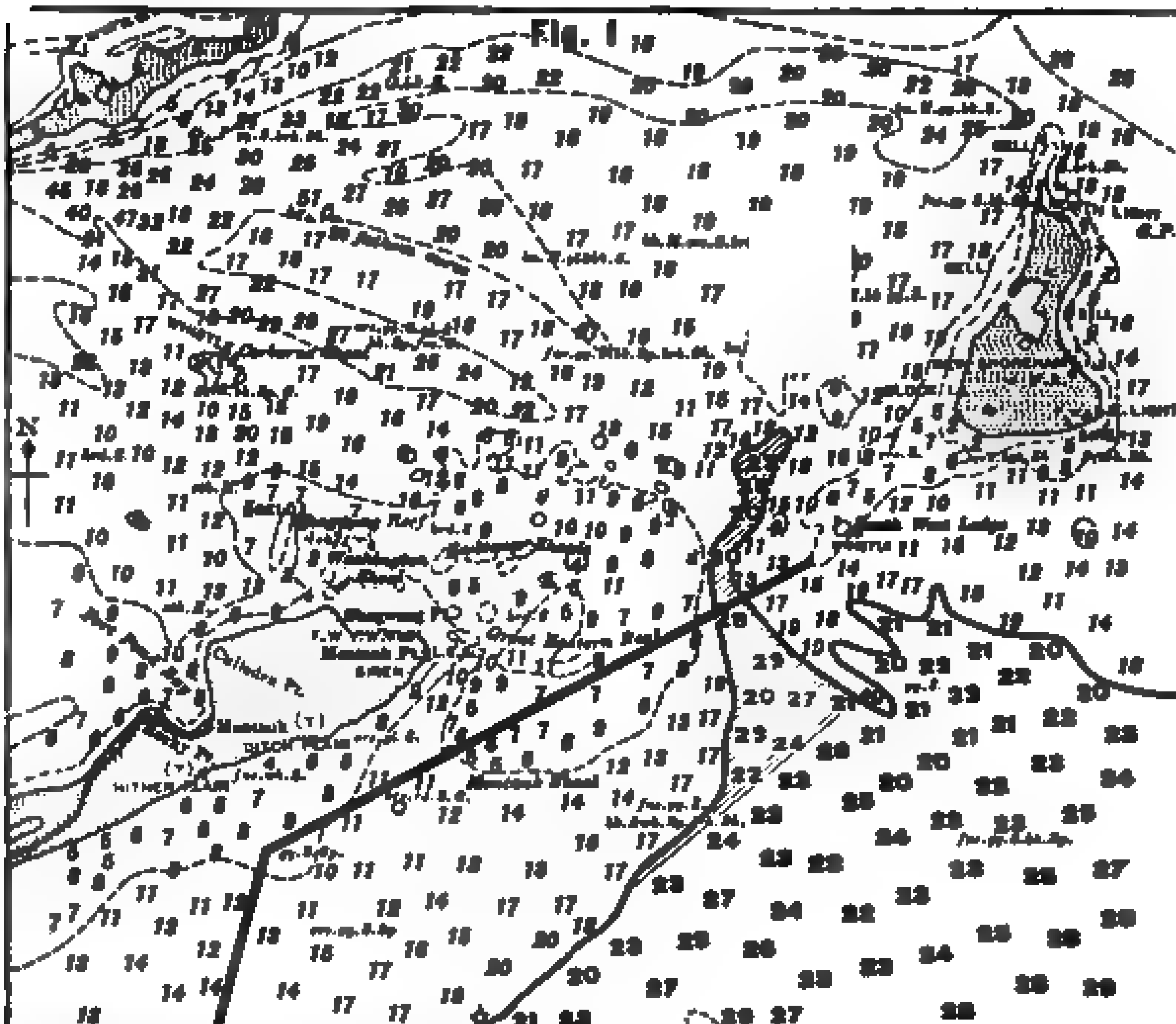
Where two ships are passing at a bend, it will be easier for them to pass clear if the one going with the current turns inside the other. This does not mean that they are privileged to pass in this way, if contrary to the Rules of the Road, nor indeed that they are justified in trying to pass at a bend in this way or in any other. If, however, they are going to pass, and if the rules permit them to pass in this way, it will be comparatively easy to pass without accident while the other way would be very dangerous. See Figs. 5 and 6, Plate 136.

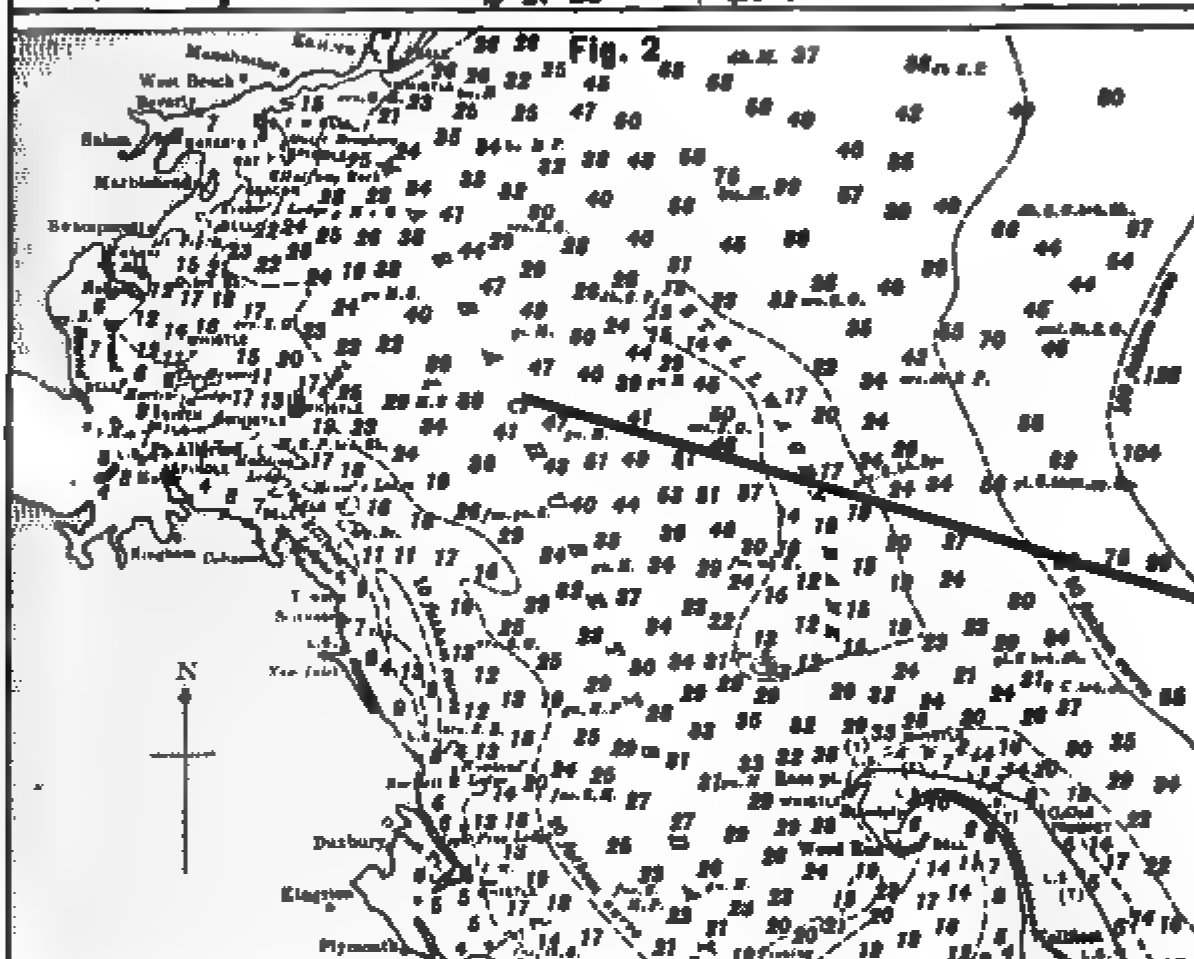
§ III. NAVIGATING IN A FOG.

The phase of this subject which has to do with the avoidance of collision is fully discussed in Chapter "Manœuvring to Avoid Collision," where it is shown that the law requiring ships to run at "moderate" speed is perfectly reasonable as a matter of seamanship, and that a ship running at such speed, and having, as she should have, a reserve of power for backing hard, can be stopped in from one to three times her length. It is clear that the same considerations which make this reasonable for the avoidance of collision make it equally so for the avoidance of stranding; but there is another point to be considered here, which is that the effect of currents in throwing the ship out of her reckoning will be greater at a low than at a high speed, their effect varying, in fact, inversely with the speed. This should always be taken into consideration and may under some circumstances constitute a reason for running at higher speed than would otherwise be justifiable.

Experiments with fog-signals have proved that such signals are often inaudible at distances much within that at which they should be heard; and furthermore that a signal which has been heard at a certain distance may be lost *as it is approached,* there being, apparently "zones of silence" surrounding the signals, in which the waves of sound are deflected upward. This has been shown to be a matter of sufficient practical importance to be a source of real danger.

Plate No. 137.





SIGNIFICANT SOUNDINGS, FIXING POSITION IN A FOG.

Through the development and very general introduction of the *Gyro Compass,* the *Radio Compass,* the *Submarine Signalling System* and the *Sounding Machine,* all of which are described in Chapter VIII, the difficulties and dangers of navigation and especially of navigation in a fog, have been enormously reduced.

With these should be associated a reliable system of determining the speed of the ship (by patent log or revolutions of the screws), and from these the distance run (with course made good) for any desired interval of time.

It is often possible to fix the ship's position with surprising accuracy by sounding alone, the soundings being plotted on tracing cloth to the scale of the chart with proper courses and distances between, and the cloth moved over the chart until a position is found where the soundings as plotted fall in with the depths given on the chart. It is convenient to draw a number of meridian lines on the tracing-cloth as an assistance in laying off the courses and in keeping these true to the chart while moving the tracing about. The lead is "armed" for each sounding and the sample of bottom brought up should be recorded as carefully as the depth, and given equal weight in locating the position.

It will be understood, of course, that this method of navigating is available only on coasts that have been thoroughly surveyed and accurately charted.

An examination of the chart will often reveal an exceptional formation of the bottom which may be as characteristic as a conspicuous peak or other peculiar formation on land, and as conclusive in establishing a position. Two important illustrations of this are shown in Plate 137. Fig. 1 shows the soundings at the eastern entrance of Long Island Sound. Here a long, narrow "deep" makes up at right angles to the line connecting Montauk with the southern end of Block Island.

A vessel standing in here in a fog and in doubt about her exact position, could run slowly to the eastward in 7 and 8 fathoms, getting soundings in quick succession. If the soundings increased suddenly from 7 fathoms to 25 or 30, and immediately afterwards decreased almost as suddenly, the position would be fixed as if the fog had lifted and shown the land. Similarly, a vessel standing in for Boston and getting soundings on Stellwagen Bank, would have almost a perfect fix (Fig. 2).

It often becomes necessary in a fog or in weather too thick for sights, to run along a coast or to round a bend, keeping at a certain distance from land. Where the soundings run with some degree of regularity, as for example, along the Atlantic coast of the United States, a certain depth of water (or two limiting depths) may be selected from the chart and the ship kept approximately on the curve of this depth by heading out or in a little as the soundings are found to decrease or to increase. Thus a steamer having to run in thick weather from Boston to Key West could round Nantucket shoals in depths from 28 to 35 fathoms, then striking across to the 20-fathom curve on the coast of New Jersey could follow this curve with safety to Cape Canaverel.

In running a channel where the water shoals gradually on each side, the ship may be kept in the channel by zig-zagging slightly from side to side, the course being changed whenever the water is found shoaling dangerously. The advantage of running more or less across rather than attempting to follow the channel directly is that when the water begins to shoal, we know in which direction the course must be changed to deepen it, whereas if we attempt to follow the channel, and find ourselves in shallow water, we have no means of telling on which side the channel lies.

When in the neighborhood of high land, use can sometimes be made of *echoes* to determine roughly the distance of the land and whether the ship is opposite a bluff or a break in the contour of the coast.

§ IV. BUOYAGE.

The International Marine Conference of 1889 suggested a uniform system of buoyage based first upon color and secondarily upon shape. The following extract from the report of the committee having this subject in charge, puts very clearly the principles which should be included in such a system. These principles have been to a considerable extent adopted by the leading commercial nations of the world, as will be seen in the appended Notes on Buoyage.

Extract from Report of Committee on Buoyage:

"The term starboard hand shall denote that side of a navigable chan-

nel which is on the right hand of the mariner entering from seaward; the term port hand shall denote that side which is on the left hand under the same circumstances.

Color.—Buoys defining the starboard hand shall be painted a single red color.

Buoys defining the port hand shall be painted a single black color, or a parti-color.

Buoys defining middle grounds shall be painted with horizontal bands.

Form.—Wherever form is used as a distinctive character.

Buoys defining the starboard hand shall be conical, and those defining the port hand shall be can or spar.

Top Marks.—Countries where form is not used as distinctive character for the buoys may adopt as another distinctive feature for the buoys on either side of a channel, top marks resembling a cone to be used on the starboard side, or a cylinder on the port side of a channel.

Numbers and Letters.—Numbers, letters and names may be painted on the buoys, but they must never be so large as to interfere with their distinctive coloring.

Whenever numbers and letters are used they shall be in consecutive order, commencing from seaward.

Buoying and marking of wrecks.—(a) All buoys and the top sides of vessels used for the marking of wrecks, shall be painted green with a suitable white inscription.

(b) Where it is practicable, by day one ball shall be exhibited on the side of the vessel nearest the wreck, and two placed vertically on the other side; three fixed white lights similarly arranged but not the ordinary riding lights, shall be shown from sunset to sunrise."

It should be observed that the above are recommendations and not laws. As a matter of fact, however, the general features of these recommendations have been adopted by most of the Governments which have established uniform and consistent systems of buoyage.

As regards the marks for channels, some nations distinguish the starboard and port sides by color, some by shape, and some by topmarks. Some use two characteristics, but place more emphasis on one than on the other.

> In German waters, *conical* buoys painted black, mark the port side of the channel in entering, and spar or *can* buoys painted red, mark the starboard side.
>
> In Norway, Sweden and Russia a "*compass*" system of marking is adopted; that is to say, the colors, shapes and topmarks are arranged to indicate the north, south, east and west sides of channels and shoals.
>
> **Quarantine** buoys are invariably yellow.
>
> Buoys defining the limits of anchorages are usually white. But Belgium, Norway, Sweden, Russia and Denmark use white buoys as regular navigational marks.

In all countries, special types of buoys, beacons, etc., are used in special places and shown on charts. Such are Bell-buoys, Whistling-buoys, Gas-buoys, Electric-buoys, etc. See Appendix ("Buoyage").

In regular systems, starboard hand buoys, if numbered, have even numbers, port hand buoys, odd numbers, counting in succession from seaward.

In the Straits of Magellan and the Patagonian Channels, the buoys are placed with reference to vessels passing from the Atlantic to the Pacific, red buoys being on the starboard hand of the channel with reference to such vessels and black buoys on the port hand.

The positions and character of buoys should be given on all charts and in all Sailing Directions, and the latest authoritative information available should always be consulted before entering or leaving a port or coming on a coast.

Buoyage of United States Waters.

The following are the rules for the buoyage of the coasts and harbors of the United States and Insular possessions:

The buoys used for marking channels, dangers, etc., are called nun, can, ice and spar buoys. With the exception of the spar buoy, which is made of wood, they are constructed of sheet iron with water-tight compartments so that an accidental puncture will not sink them.

In conformity with section 4678 of the Revised Statutes of the United States, the following order is observed in coloring and numbering the buoys along the coasts, or in bays, harbors, sounds, or channels, viz.:

1. In approaching the channel, etc., from seaward, **red buoys**, with **even numbers**, will be found on the **starboard side** of the channel, and must be left on the starboard hand in passing in.

2. In approaching the channel, etc., from seaward, **black** buoys, with **odd numbers**, will be found on the **port side** of the channel, and must be left on the port hand in passing in.

3. As a rule, starboard hand buoys are *nuns*, and port hand buoys *cans*, but spars may replace either.

4. Buoys painted with **red and black horizontal stripes** will be found on **obstructions**, with channel ways on either side of them, and may be left on either hand in passing in.

5. Buoys painted with **white and black perpendicular stripes**, will be found in **mid-channel**, and must be passed close-to to avoid danger.

6. All other distinguishing marks to buoys will be in addition to the foregoing, and may be employed to mark particular spots, a description of which will be given in the printed list of buoys.

7. **Perches,** with balls, cages, etc., will, when placed on buoys, be at **turning points,** the color and number indicating on which side they shall be passed.

8. Day beacons, stakes and spindles (except such as are on the sides of channels, which will be colored like buoys) are constructed and distinguished with special reference to each locality, and particularly in regard to the background upon which they are projected.

9. Wherever practicable, the towers, beacons, buoys, spindles, and all other aids to navigation are arranged in the buoy list of the Lighthouse Board in regular order as they are passed by vessels entering from sea.

10. The navigator should keep in mind that the buoys in thoroughfares and passages between the islands along the coast of Maine are numbered and colored for entering *from the eastward.*

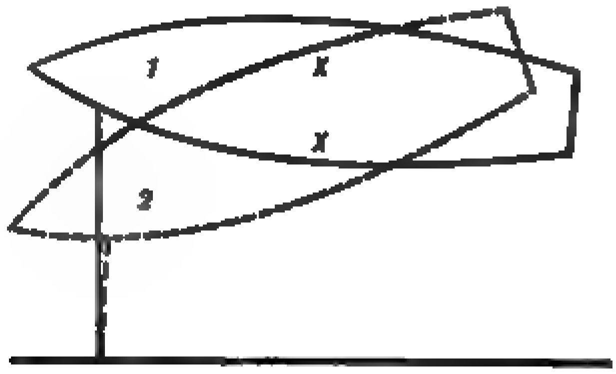


Fig. 1

Fig. 2

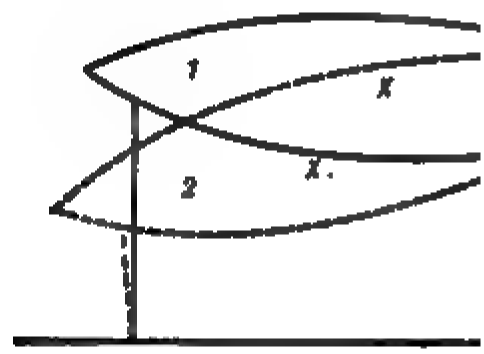


Fig. 3

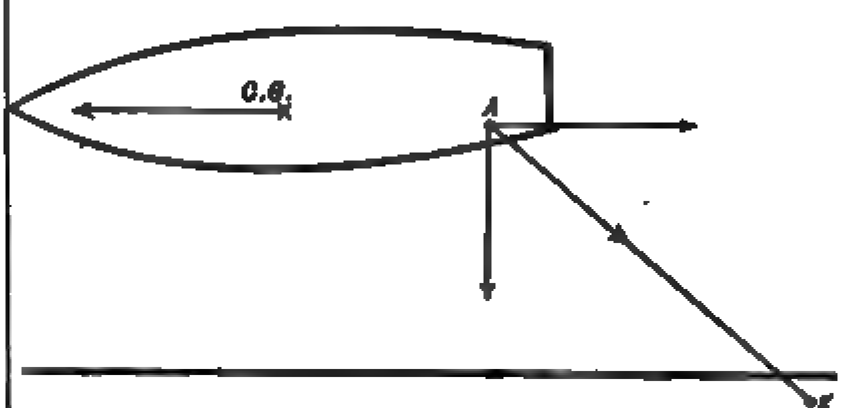
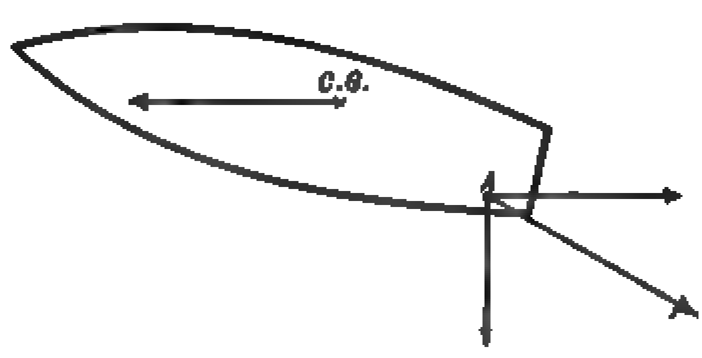


Fig. 4



STEAMERS AROUND A DOC

CHAPTER XVII.

HANDLING A STEAMER ALONGSIDE A DOCK.

§ I. PRELIMINARY.

It is clear that the conditions under which work of this kind is to be done may vary almost indefinitely and that the methods used must be varied correspondingly. It would be hopeless to attempt to illustrate all or even any considerable number of the situations which arise in practice, but it is not so difficult to analyze in a general way the various factors involved, and to show their application to a few special cases.

The factors are: lines, helm, screw, headway or sternway of the ship, current, wind.

We begin by considering the use of lines, first alone, then in combination with other factors.

CASE. I.

If the ship is lying dead in the water abreast of a dock, as in Fig. 1, Plate **138**, with a bow line leading to the dock, hauling on this line will turn the bow in, of course, but it will also throw the stern out, the ship pivoting about the center of gravity. It should be noted, however, that the stern does not go out quite as much as the bow comes in; for, since the ship is not held rigidly at the pivoting point, the mass as a whole will respond more or less to the force acting on the bow, and the resultant motion will be like that shown in the figure.

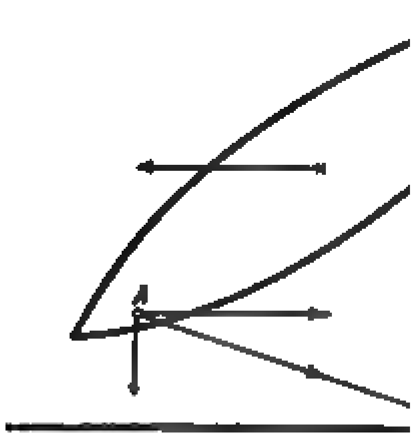
If the stern is held by a line to the dock, as in Fig. 2, Plate **138**, the pivot is transferred to the stern and the whole length of the ship comes in as shown. This requires much greater effort than to turn the ship about her natural pivoting point as in Fig. 1.

If the bow and stern lines are hauled on at the same time, the ship may be breasted in bodily, but at an even greater expenditure of work than in the preceding case.

If either of the lines described above leads off at an angle from the beam, it constitutes a "spring," which may be defined as a line diagonal to the keel and exerting a force, when power is

[1] See also Chapter XXI, "The Handling of Destroyers."

Fig. 2



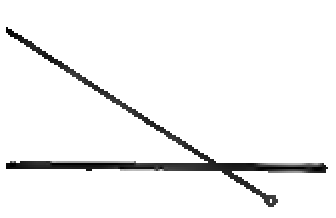
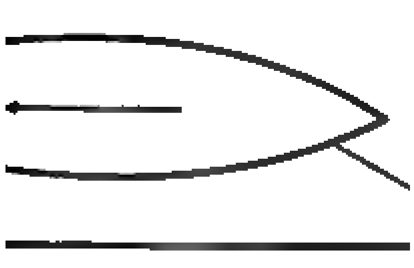


Fig. 4



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applied to it, both in the direction of the keel and at right angles to that direction.

A spring is used, therefore, for moving the ship ahead or astern and breasting her in at the same time.

CASE 2.

If the ship has way, either ahead or astern, her ***momentum*** enters into the problem of her behavior. We have here another application of a spring, the power involved in this case being furnished by the ship itself.

In Fig. 3, Plate **138**, suppose that the steamer shown is moving parallel to the face of the dock with engines stopped and helm amidships, and that the stern spring A K is taut. Disregarding the resistance of the water, which is inconsiderable, the motion of the ship will be that resulting from her momentum along the original course and the tension along A K. The tension on A K may be resolved into two components; one retarding the ship along the line of her original course and thus directly opposing the momentum, the other hauling her in toward the dock and tending at the same time to turn her about the center of gravity, drawing the stern in and throwing the bow out. It is important to note, however, that the momentum, which is concentrated at the center of gravity, *forward of the pivot*, opposes the turning and tends to keep the ship straight. Thus as a matter of fact the ship does not turn much in cases of this kind, but comes in nearly parallel to the dock (Fig. 4, Plate **138**).

CASE 3. (Figs. 1 and 2, Plate **139**.)

If the vessel is moving as before, but with a spring from the bow instead of from the stern, the forces acting are similar to those in the preceding case, but with an important difference. In the present case, the momentum acts to increase the turning effect of the spring, instead of opposing it. This will become clear if Fig. 2, Plate **139**, and Fig. 4, Plate **138**, are compared.

The result of this difference is that the *bow* of a ship moving ahead on a bow-spring turns sharply in toward the dock, whereas the stern is turned in very little, if at all, by a stern-spring.

If the ship is moving astern, instead of ahead, the conditions are of course reversed, a stern-spring turning the stern in sharply, while a bow-spring has little effect.

Evidently, in both of the preceding cases, the turning moment is greatest when the line is made fast at the extreme bow or stern. If it is made fast at the center of gravity, the ship should (theoretically) spring in without turning, provided her draft of water is the same forward and aft. We shall presently see that if the helm is to be used (as in practice it always is) the maximum control of the ship will be obtained when the line is made fast at some point intermediate between the end of the ship and the center of gravity.

CASE 4.

Suppose that the vessel of Case 2 (Figs. 3 and 4, Plate **138**) puts her helm to starboard with a view to throwing her head in. Since the steering effect of the rudder is chiefly a matter of moving the stern of the ship, and since the stern cannot be thrown off to starboard because it is held by the spring, it follows that starboard helm can here have comparatively little turning effect. This assumes, of course, that the line is made fast over the rudder. Port helm, on the other hand, will help materially to throw the stern in.

If in Case 3 (Figs. 1 and 2, Plate **139**) the helm is put to starboard, it will throw the stern off and greatly increase the rapidity with which the bow turns in. If put to port, it will oppose the turning, but not enough to overcome it.

If in any case we make fast the line at the center of gravity while the ship is working ahead, we shall spring the ship in bodily but can at the same time *steer* her by putting the helm over, throwing the stern to either side as desired; the ship swinging on a pivot under the influence of the helm, while coming bodily in on the spring.

If the line, instead of being made fast amidships, is taken to a chock between the midship point and the stern, say midway between, we gain a considerable steering power, without entirely sacrificing the turning tendency of the spring. In practice, the spring is usually taken to this point—or to the corresponding one between the midship point and the bow—and this is found to give a convenient balance of forces and to admit of working in with the ship under good control (Fig. 3, Plate **139**).

CASE 5.

If we add to the factors already considered, the effect of the screw, going ahead or backing, we have the conditions of actual

practice in cases where the tide is not strong enough to be considered.

So long as the screw is turning *ahead* it has a powerful steering effect through the action of the discharge current against the rudder, driving the stern off to the side to which the helm is put, the bow being held in by a spring. In *backing*, its effect may be utilized to throw the stern to one side, but not to the other. If it is right handed, it will throw the stern to port and cannot be prevented from this even by hard over port helm. It is for this reason that single-screw steamers (right handed) are most easily put alongside with the port side to the dock. They can run in at a considerable angle, then stop and back and so straighten up parallel to the dock, whereas with the starboard side in, backing would throw the stern further off.

Vessels with twin-screws have the same advantage in working around a dock that they have in manœuvring elsewhere; that is to say, the screws can be utilized to turn the ship even when she has no steerage-way, and when, therefore, the rudder has little effect. This use of twin-screws—going ahead on one and backing the other—is obvious enough; but there is another application which can be made of them which is often overlooked. As noted above (and as explained at considerable length in the chapter on "The Steering of Steamers"), a right-handed screw, in backing, throws the stern to port, while a left-handed screw throws it to starboard. In a single-screw steamer we have, in this action of the backing screw, a powerful force acting to one side, which may be utilized with great advantage *if we wish to throw the stern to that side.* If it happens that we wish to throw the stern to the other side while backing, or to hold it steady, then this action of the screw is a disadvantage, and often a serious embarrassment. But in a twin-screw steamer we have *both a right-handed and a left-handed screw,* so that we may, in backing, throw the stern to either side by using the proper screw. It is the general practice to put the right-handed screw to starboard and the left-handed screw to port. If, therefore, we wish to throw the stern to port while backing, we back with the starboard screw alone; and it should be noted that not only does the direct action of the screw throw the stern to port, but the leverage due to the position of the screw (to starboard of the center of gravity) acts in the same direction. Similarly, if we wish to throw the stern to starboard, we back on the port screw alone.

Effect of a Current.

If there is any current, it must of course be reckoned with and may be the most important factor in the situation because the one which cannot be controlled. Slack water is the most favorable time for working around the dock; but a head tide, if not too strong, may be used to advantage. A fair tide is unfavorable, and should be avoided if possible in coming alongside. A weak tide setting on to the dock may be helpful, but a strong one is very dangerous. A tide setting off increases the difficulty of the situation, but reduces its danger.

In considering the effect of the tide, it must be remembered that a vessel with a current on the bow not only has her headway checked, but is set bodily off to the opposite side. For this reason, care must be taken to avoid getting too much of a cant across, as this may result in being set in with dangerous violence.

A ship held stationary in a current, whether by her own power or by a line, may be canted to either side by the use of the helm, exactly as if she were moving through the water. Thus, with a head tide, a line may be run out from the bow to the dock well ahead, and the ship dropped in by the tide alone, the speed with which she comes in being regulated by the helm.

§ II. PRACTICAL CASES.

In considering the handling of a steamer around a dock, a distinction must be made between the case in which she uses her own power alone and that in which she is assisted by one or more tugs. All very large vessels are now handled by tugs and it would be the height of imprudence to attempt to dispense with them. But vessels which would formerly have been considered very large are constantly worked in and out with their own resources alone. Such are the splendid vessels of the Sound and Bay Lines of the United States, some of which are side-wheelers and others propellers. These vessels run on schedule time and without reference to tides. They are brought alongside their piers often under the most unfavorable conditions, and rarely meet with an accident. It should be noted, however, that these vessels are especially designed for this business of docking under all conditions of wind and tide. Most of them have guards extending much farther out from their sides than any of the projections which might interfere with docking.

The Marine Superintendent of one of the large Atlantic steamship companies writes to the author on this subject as follows:

"In my opinion, the great secret in handling either a twin-screw or single-screw steamer in approaching a pier, is not to have too much way on the ship; the engines should be slowed and the way off the ship so that she can be kept well in hand at such a distance from the pier, that if it should be necessary to go ahead in order to cant the ship's head either one way or the other by the use of the rudder, it can be done without the ship's overrunning the place where she is required to land. The ship should be kept thus in command until she gets into a position where she can be stopped entirely by moving the engines astern, without risk of her bows striking the pier, or of her getting out of position by her head canting off by the action of the propeller moving half or full speed astern. If the pier is approached in this manner, after a little practice it is astonishing how close even the largest vessels can be brought to the pier without danger of colliding. Large steam vessels should always approach a pier against the tide, and as near parallel with the direction of the tide, or trend of the river, as possible. The practice of heading a ship from the river between two piers is a very doubtful and frequently dangerous operation; for, although the tide may be slack on the surface it may be running smartly either flood or ebb for a few feet below."

Handling a Steamer without Tugs.

Having to go alongside, if there is any choice in the matter, select a time as near as possible to slack water; which, it must be remembered, does not necessarily or usually correspond to high or low. If any current is running, manœuvre if possible to bring it ahead, running beyond the pier and turning if coming in with the flood. With a single-screw steamer, there is an advantage in putting the port side to the dock (supposing the screw to be right handed) but this is of less importance than is the direction of the tide.

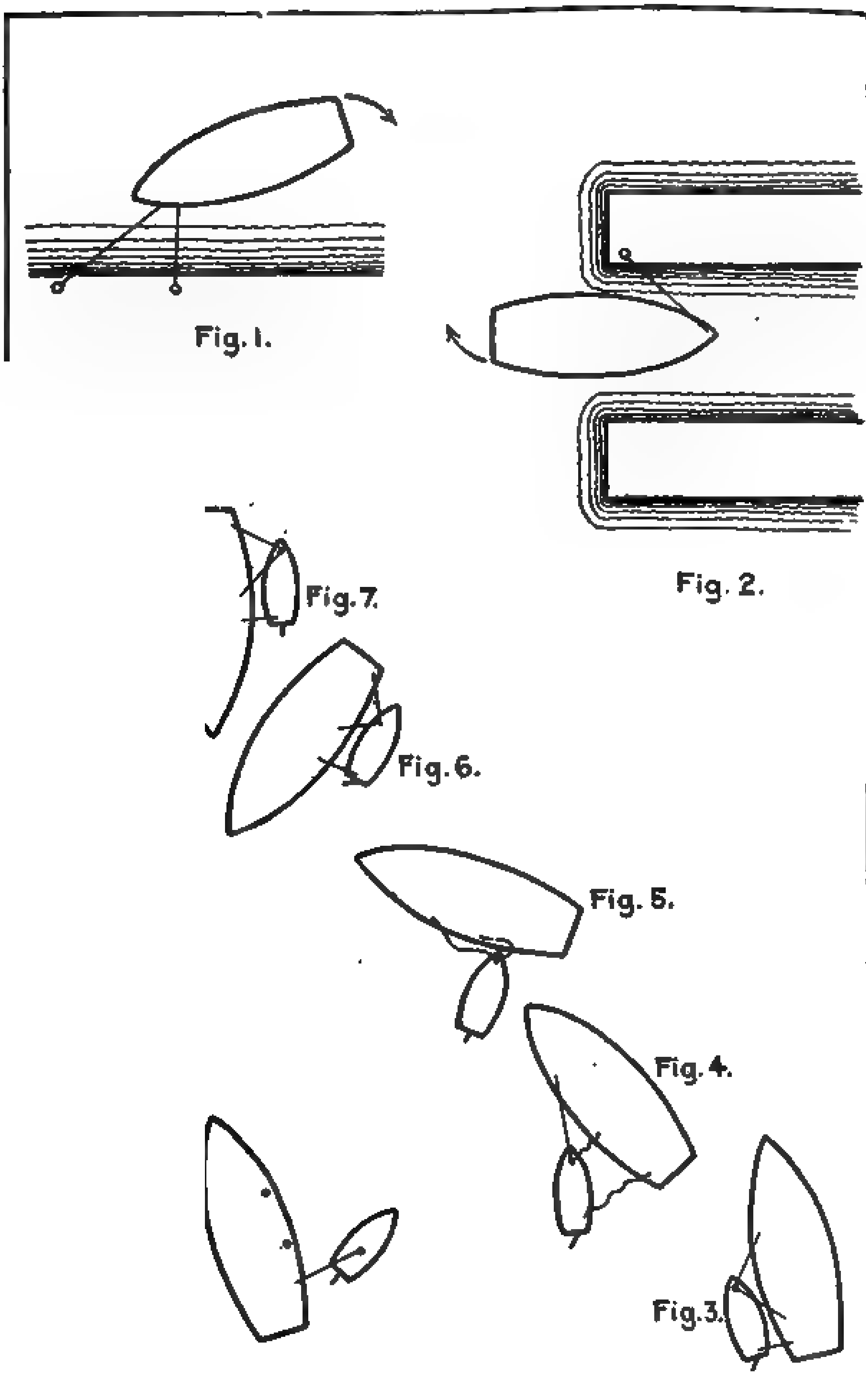
A vessel does not go alongside without some preparation hav-

bent, anchors ready for letting go, capstans and winches ready for heaving, boat-davits and every thing else alongside rigged in or cleared away as far as possible. Most merchant vessels are designed with some reference to going alongside, although it is impossible in any ocean-going vessel, to avoid the projection of boat-davits and some other obstructions. In men-of-war there are also guns and sponsons to be considered; and in twin-screw ships, whether men-of-war or merchantmen, the screws project many feet beyond the side and constitute a danger which must never be forgotten for a moment. To keep these vessels off, there are usually provided floats or "camels"; and these must be hauled into position by the shore gang at the points where they are seen to be needed.

The simplest case that can arise is that in which a right-handed screw vessel is to be put alongside at slack water and port side to the dock. Here she is run in at a small angle to the face of the dock, and the engines backed in time to throw her stern in and straighten her up. This does not mean that she should come in at such speed and at such an angle that if the signal to back is misunderstood or if the engines are slow in responding, the bow will crash into the dock. Other things being equal, the more nearly parallel to the dock she is brought in, and the lower the speed used, the better; but as some backing will probably be called for and as the effect of this will be to throw her stern in, a little allowance should be made for it.

Another way of making a landing under the above conditions is to get out a line from the quarter, and, going ahead very slowly, spring her in on this, using the helm to hold her parallel to the dock. A line used in this way must be carefully attended and checked slowly as the tension on it approaches the danger point. It should preferably be taken from a chock about half way between the midship point and the stern, as this gives good control of the ship by the helm as she comes in.

Under the same conditions, if the port side is to the dock, she might be sprung in by backing on a bow line, but this is not so good a way, since the control of the ship in backing is altogether unsatisfactory. If the starboard side is to the dock, the effect of backing would be to throw the stern off, so if this method is to be used, a stern spring will be needed in addition to the bow spring (Fig. 4, Plate **139**). The use of two springs like this is very common.



IG AROUND A DOCK, TURNING A TOW.

A *twin-screw* ship may be backed down on a bow line and sprung in with comparative ease, the helm being used to keep her fair with the dock, and the right- and left-handed screws used as has been explained above.

Here it will be helpful to use a bow-breast with the spring as in Fig. 1, Plate **140**, coming in with a decided cant toward the dock, and getting the lines to the dock as shown, the breast being taken from as far forward as is convenient. Now by backing on the off screw we drop alongside.

It sometimes happens that a ship is going into a slip with very little room, as in Fig. 2, Plate **140**, and it becomes necessary *to check her without canting her.* The bow spring shown, if used alone, would cut her bow in sharply. Here we may check her with two forces which will act together for checking her way, but oppose each other for canting. These are the spring on the inner bow, and the screw (backing) on the outer quarter. This is often a very valuable combination of forces.

If there is a head tide, the vessel may be brought up with hardly more than headway enough to stem it until a bow spring is run, then allowed to drop back on this by the tide and so come in to her berth. Care will be needed to see that she does not get too strong a cant across, as this would set her in with dangerous force. She can be steered without difficulty by the helm, giving a turn ahead with the screw if necessary from time to time. In this way a vessel may drop in from a considerable distance out. She may even dispense with the line for coming in, taking the tide a little on the bow and letting this set her in bodily; care being taken, as before, that she does not come in too fast, the helm and engines being used to straighten her up when necessary.

It does not always happen that the tide sets parallel to the face of the dock. More frequently, it sets on at more or less of an angle, and the angle often varies with the stage of the tide. At Old Point Comfort, for example, the current at one stage of the ebb runs along the face of the dock, while at another stage it sets directly on. Between the two extremes, it turns slowly from one of these directions to the other. Similar phenomena to this are common in all places where fairly large bodies of water are involved and especially where the channel bends or where several channels meet. Another point to be remembered is that the surface current often has a very different direction from that

which is running underneath. Considerations like these make it clear that local knowledge is essential for docking ships with safety, and suggest that in places where the phenomena of currents may prove to be complicated, a stranger having to dock his ship should seek the assistance of a pilot with full knowledge of local conditions.

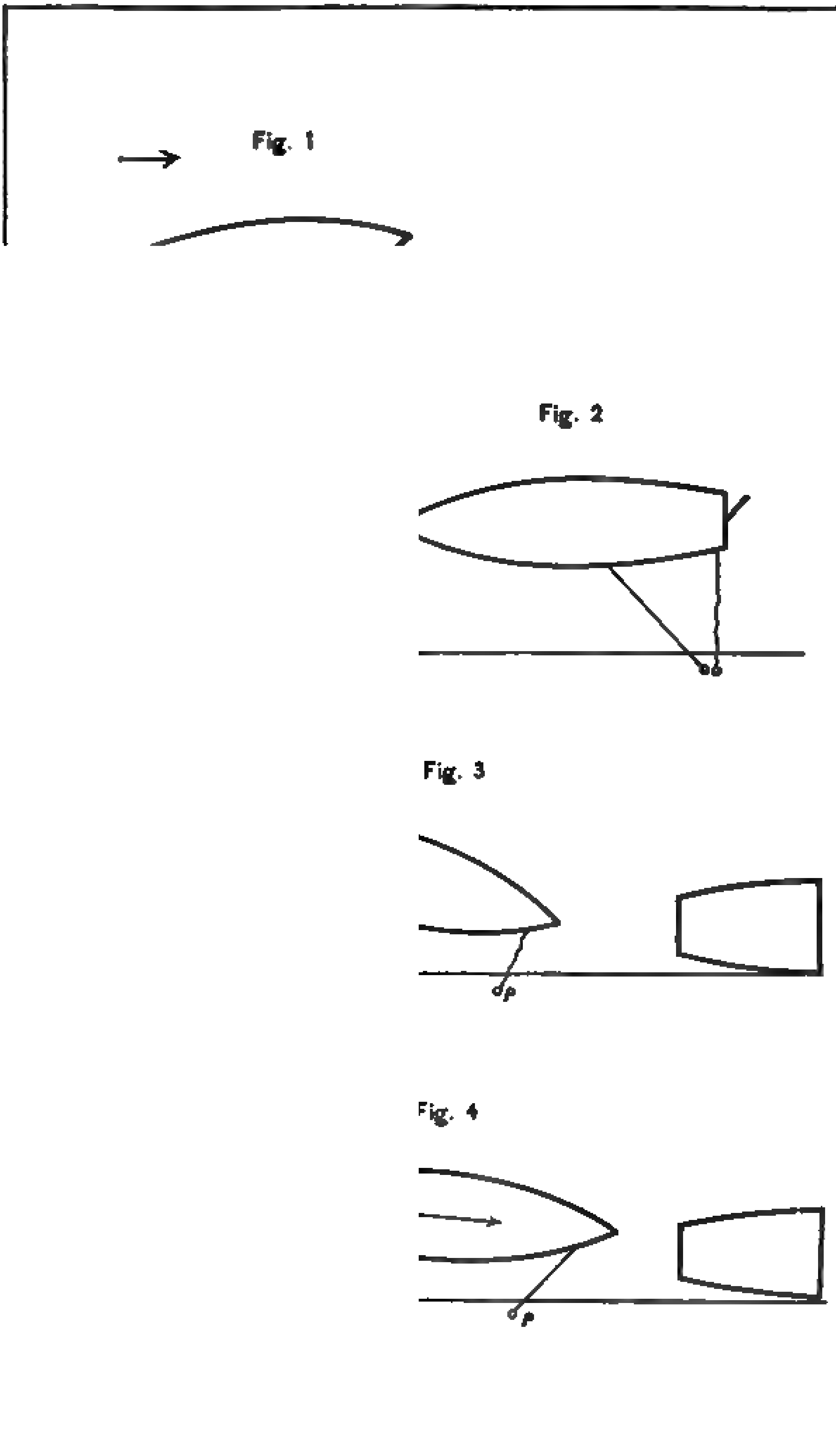
If it should be necessary to make a landing with a fair tide, preparations must be made to get out a stern line promptly, and the vessel should be brought abreast her berth (or a little astern of it) *with a slight cant of the head outward* (Fig. 1, Plate **141**). This will prevent danger of the current catching her stern on the inside and sweeping her off while the line is being made fast, as might happen if her head were canted in.

It is an invariable rule that with a fair tide, the ship must be sprung in with a stern line, never with a bow line alone; and the same rule applies in springing her in by her own headway. In either of these cases, the effect of a bow spring would be to throw the stern off, while a stern spring, for reasons which have been explained in Section I, brings her bodily alongside.

If the dock is not clear ahead and astern of the berth to be occupied, other means must be employed. The vessel may be laid abreast her berth as close in as practicable, and hauled in one end at a time by lines taken to winches. In this case, if there is no tide, the stern should be hauled in first, the bow line being slack and the bow allowed to swing out as the ship turns. This because it is always harder to haul in the stern than the bow, owing to the drag of the after body and the screw. The stern, having been hauled in somewhat, is held from swinging out by a breast line, and the bow is hauled in. The operation is then repeated if necessary, the stern being held in each time while the bow line is manned, but the bow being allowed to swing out a little each time as the stern comes in. Thus the working in of the stern is a matter of *turning* rather than of dragging in bodily, while with the bow, the reverse is the case.

If circumstances admit of going ahead somewhat, the following method is perhaps the simplest that can be employed. A spring is run from a point well forward but still abaft the center of gravity, and a breastline from a chock near the stern to a point on the dock nearly abeam (Fig. 2, Plate **141**). The screw is started ahead slow with rudder hard right[1] (supposing the port side is to the dock) and the stern swings in on the spring,

[1] Helm hard aport.



RS AROUND A DOCK

Fig. 1

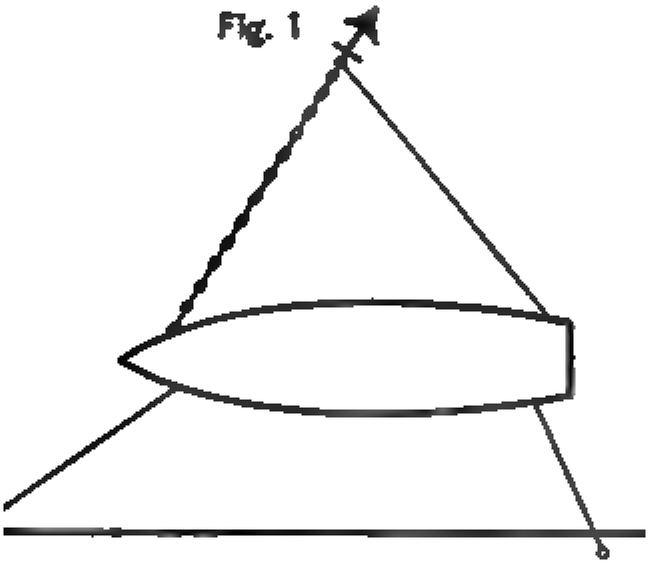


Fig. 2

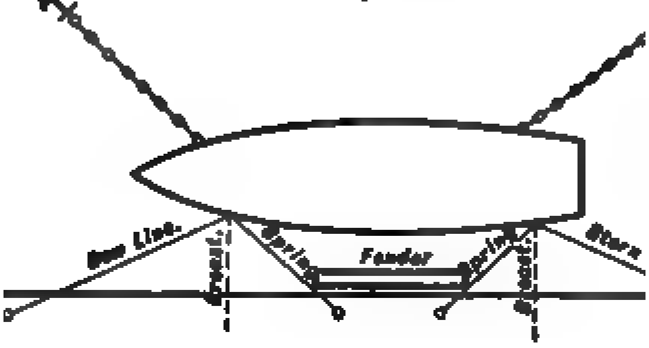
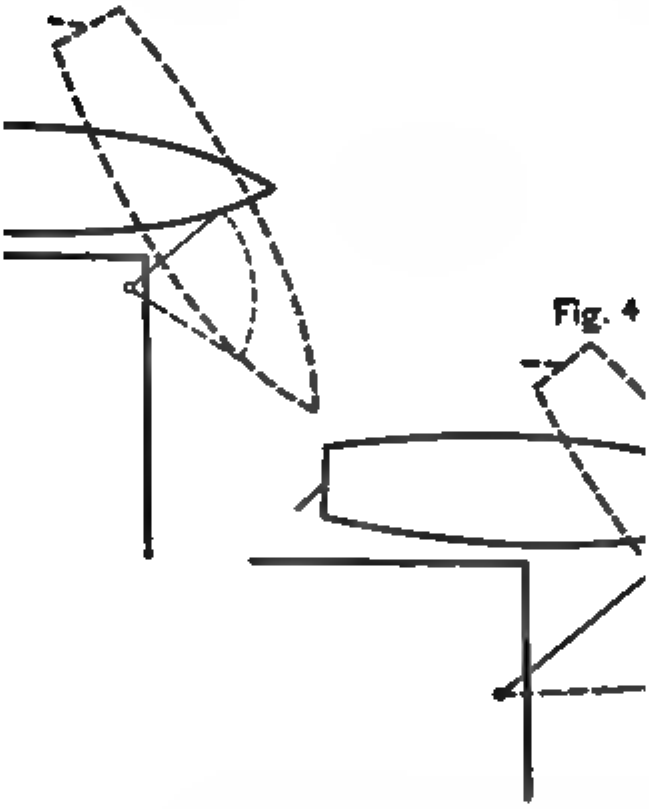


Fig. 4



.ING STEAMERS AROUND A D

from the effect of the port helm. When she is canted as much as is thought best, the stern breast is hauled taut and held, and the helm shifted to hard a-starboard, the engines being kept ahead slow. The starboard helm now tries to drive the stern off, but the breast holds it, and, as the ship forges ahead on the spring, the bow turns in and is held by a bow breast. The helm is presently shifted to hard aport (the engines all the time going ahead) and the stern comes in again. The operation is repeated as often as may be necessary; care being taken, if a current is running, to avoid getting too much of a cant.

Still another way of working into a restricted berth is shown in Figs. 3 and 4, Plate **141.** This supposes that there is no tide. Come in at such an angle as may be necessary to clear the danger astern, putting the bow close enough to get a line ashore to some point as P, abaft the point where the bow is to be when secured. Go ahead with left rudder,[1] which will throw the stern in, leaving the bow line slack until the stern clears the danger; then hold on the bow line, still going ahead with starboard helm. This brings her into her berth.

Under many circumstances, as for example when proposing to lie for some time at an exposed dock, an anchor should be let go outside and some distance ahead of the berth to be occupied, and the ship dropped or hauled in from this by the aid of bow and stern lines to the dock. With a head tide, a judicious use of the lines and the helm will make it possible to drop in with little or no hauling, but she must be straightened up toward the end to avoid coming in too heavily. If an anchor is needed from the quarter, this must be laid out later by a boat.

With a fresh breeze or a current setting on to the dock, it may be possible to drop in by letting go an anchor abreast of the berth with a spring from the quarter made fast to the ring (Fig. 1, Plate **142**); bow and stern lines being used as before.

Fig. 2, Plate **142,** shows a vessel secured to the face of a dock with bow and stern lines, bow and stern breasts, and with offshore moorings for holding her off.

§ III. WORKING INTO A SLIP.

Where a vessel is to be worked around into a slip, she usually makes a landing first at the outside of the pier and is then turned

[1] Starboard helm.

either ahead or astern around the corner, swinging on a spring from near the end of the dock. It is easier to put the bow in than the stern, because of the use which may be made of the helm for steering around and into the new berth. Account must be taken of the current, and allowance made for the fact that its principal effect will be felt upon the part of the vessel which swings out into the stream—not upon the part inside the slip.

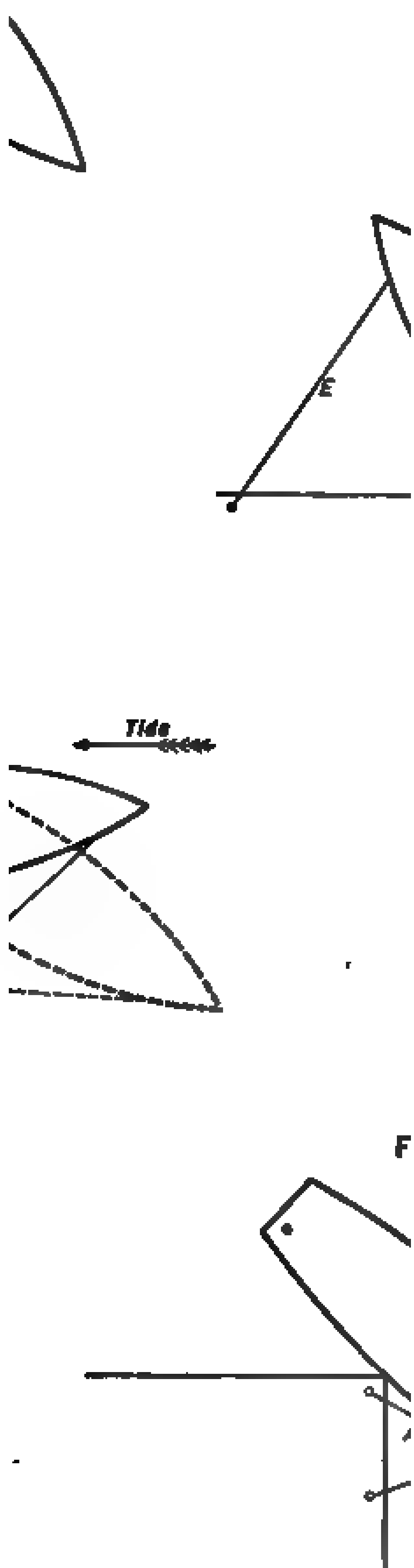
We consider first the case in which there is no current (Fig. 3, Plate 142). The vessel goes ahead sufficiently to bring her bow well beyond the end of the pier, and a line is taken from the bow to a point on the pier near the corner around which she is to turn. If the line is made fast close to the end of the pier, the tension on it is nearly a straight pull, and the turning effect is very slight. It should therefore be taken a short distance up the slip, to give a good turning effect with comparatively little strain upon the line. If, however, it is taken up too far, the ship will make a large sweep in coming around, going over to the farther end of the slip. The same effect will be produced if the bow is allowed to lap too far beyond the pier before the spring takes the strain. The effects of different conditions here may be foreseen in any given case by remembering that the point of the ship at which the line is made fast will follow the arc of a circle around the bollard on the pier.

The spring may be greatly assisted and the tension on it relieved, by making use of the helm to swing the stern out at the beginning and to steer her into place after she is pointed fairly in.

In the early part of the turn, the bow of the vessel will hug the corner of the pier, owing to the lead of the spring and the disposition of the ship to turn about her own center of gravity, throwing her stern out and her bow in. Toward the end of the turn, the same factors act to throw her off, although if rather a short spring is used, her bow will always be held in more or less closely. If it is not desired to hold her close in—because of boats or guns which might be endangered—her bow should be allowed to lap well over beyond the pier before beginning to turn, and a longer line used. The line should also be made fast farther aft on the bow, and taken farther up the slip, and the helm put hard over in the beginning. All of these points will tend to prevent binding against the corner as she turns (Fig. 4, Plate 142).

If the spring used is a short one, it will presently have a lead too nearly in line with the keel to continue its turning effect at

Fig. 1



STEAMERS AROUND

a favorable angle, and will, if continued in use, be subject to an undue tension (A Fig. 1, Plate **143**). It should be replaced before this point is reached by another line, B, having a better lead.

In making use of two lines in a case of this kind, where the lines must cross, care should be taken to keep the line which will be first let go, under the other.

A stern line is commonly used as shown at C, but in this particular case, there being no current and the vessel being under control by the helm, this line is not important.

In *backing* around into the slip, the same principles hold; but here the helm is not of much assistance, although it should be used and will help somewhat. In this case, a bow line (E) is needed to keep control (Fig. 2, Plate **143**).

If there is a current, it must of course be allowed for. If proposing to work against it, as in Fig. 3, Plate **143,** we must remember that the ship will be set down hard against the corner of the pier until she is fully inside the slip, and that a great deal of power will be required to overcome the effect of the current acting against the quarter as the stern is thrown out into the stream. Here there will be an advantage in using a comparatively long spring and allowing the bow to project well beyond the pier before beginning to turn. The tendency to swing out from the pier will be counteracted by the tide. It will be especially important under these conditions to shift the spring before it leads too nearly fore and aft. A vessel held as in Fig. 4, Plate **143,** for example, would probably not turn at all, while she would put a tremendous strain upon the spring. The whole situation is modified by substituting the line B for A. The vessel can now gather headway (going ahead with her engines), and work into place. The second line, (B), having been run, A is eased away until B has the strain, after which A may be shifted up the dock, and take its turn later as replacing B.

A large vessel could not be turned in this way against a strong tide without the aid of tugs to pull her stern around.

If the tide is fair, as in Fig. 1, Plate **144,** the danger is that as the stern swings out into the stream it will be swept around with such force that the stern line cannot hold it. This line (technically the "swinging" line) should be a good one and carefully attended by several men. The spring should be short and taken from a check not very far forward. It will then help to

hold her up, at the same time that it springs her around. As she swings out, the swinging line must at first be eased away roundly; but there will presently come a time when, as she moves into her berth, this line slacks up, and the slack must be gathered in rapidly to prevent her being swept down across the slip. At the same time, the spring, having done its work by pointing her fairly in, is let go, and she is steered inside, bow and stern lines being used to hold her in to the pier. These lines should be shifted frequently and used principally as *breasts*, not as springs. If her stern has swung too far over, it may be sprung in by the original swinging line or by another spring run for this purpose.

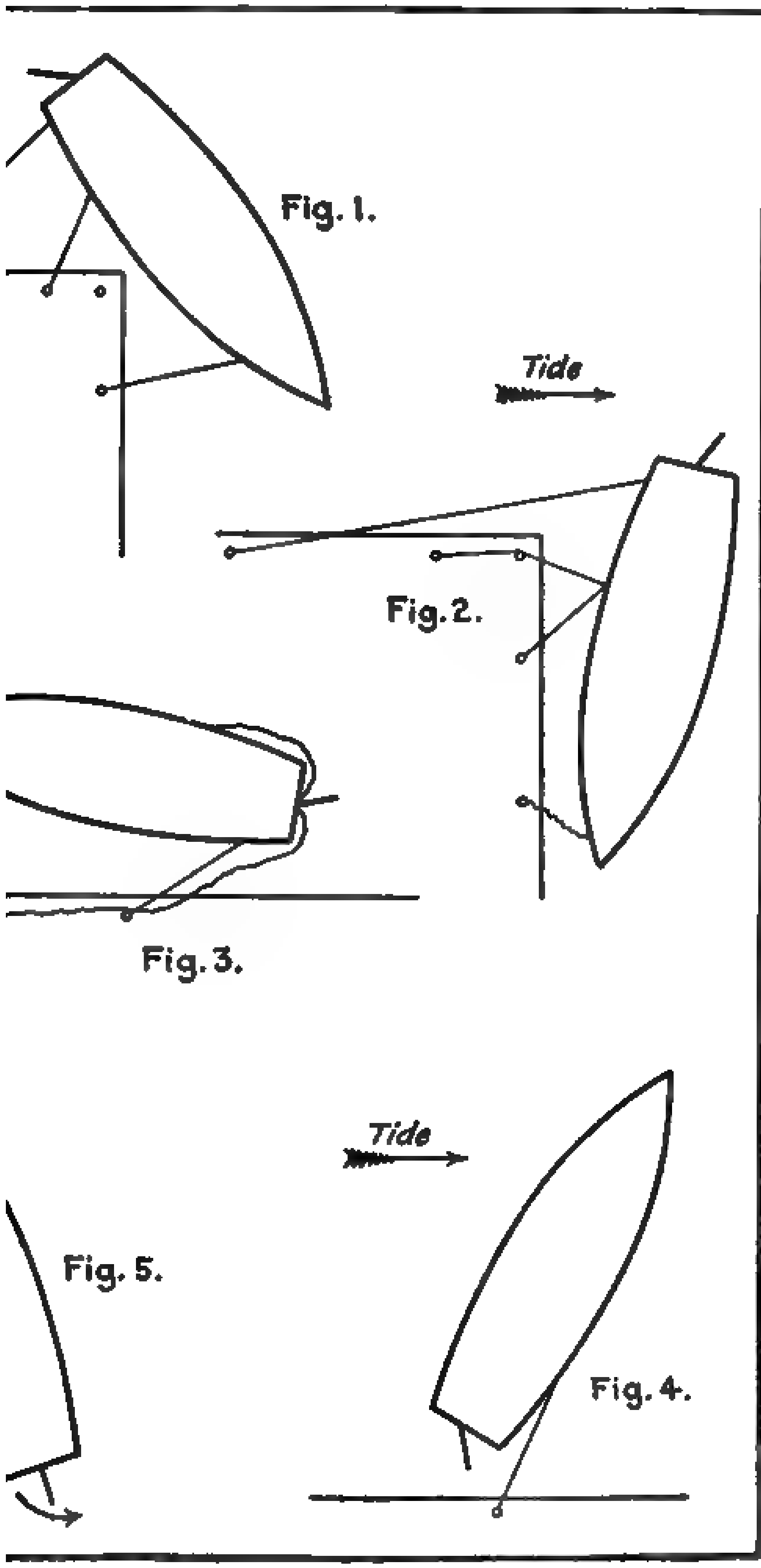
With a large ship and a strong tide, this method is not to be thought of, as the stern line would inevitably part and the stern sweep down across the slip with every probability of serious disaster.

If the ship is to be *backed* into the slip, the principles involved are the same, but the difficulties are somewhat greater because of the comparative lack of control by the helm. It should be remembered, however, that even in backing, the helm is of some value and should always be used. Even in cases where the ship is not moving through the water, the suction current of the backing screw is drawn in against the rudder, with an effect which may be utilized to more or less advantage.

For hauling into a dry dock, slack water is very important, because of the narrow space available and the exactness with which the ship must be pointed and held. A current from any direction is troublesome, but one running across is especially so

Yet if high water is essential it may be necessary to accept some inconveniences in this matter. An officer whose ship is to be docked should make himself familiar with the currents with which he will have to deal—and this none the less because the docking is usually directed by local authorities.

For hauling into the dock, the ship must be pointed fair by such means as the situation of the dock and the facilities provided may suggest. At large establishments, tugs are usually at hand for hauling the stern around. In the absence of these, lines are run from the quarter for hauling it around, while the bow is held by good lines from either side of the entrance. A line for hauling in is taken to the head of the dock, and extra lines are used wherever they may be necessary.



HANDLING STEAMERS AROUND A DOCK.

To Wind a Steamer at a Dock.

To turn a vessel end for end as she lies at the dock is a manœuvre of considerable difficulty in cases where there are no means of hauling off the bow or stern.

It may be done in a tide-way as follows: Suppose the port side is to the dock and that it is desired to put the starboard side there (Figs. 3 and 4, Plate **144**). Select a time when the tide is running feebly from ahead. Cast off all moorings but a breast forward and a spring aft. Back on the stern spring and ease away the bow breast, letting the tide catch her on the inner bow. As she cants out, let go forward and hold on to the after spring. Run a line from the *starboard* quarter fairly well forward, passing it around the stern and holding the bight up clear so that it cannot foul the screw. Make fast the other end of this line well up the dock. The tide will set her out from the dock at the same time that it swings her. As soon as the screw is clear, go ahead slow with right rudder,[1] taking care not to throw the stern in against the dock, and to keep the line from the starboard quarter clear of the screw. She will forge ahead, slacking the inner (port) spring, which may be let go and gotten out of the way. By a careful use of the helm and engines, the stern may be worked up the face of the dock but well clear of it, until abreast of the point where it is to rest when the vessel has been turned. The slack of the starboard spring is then taken in and the line made fast. As she turns, bringing the tide more and more on her broadside, she will drop down until this line holds her stern, when she will begin to swing more rapidly. As her bow turns in toward the dock, the engines may be backed if necessary to hold her stern up to its place, and even to throw it off a little from the dock if she is coming in too fast. The effect of this is to let the tide meet her a little on the inner bow as she swings in, and so to check her somewhat. It is supposed, of course, that proper fenders are in use; and here it may be remarked that in all cases of handling large steamers around docks, fenders should be used of such *length* that as the ship comes in on them, the pressure on her side will be distributed over a large number of frames, not localized at a single point.

If it becomes necessary to wind a ship when there is no tide to turn her, it may be done in much the same way as above, but

[1] Helm aport.

with a little more use of engines, helm, and lines. Her bow must first be canted out a little by such means as may be available. This may be by backing on a stern spring, by pivoting on a float, or by any other method which may be suggested by the conditions of the case. Care must be taken to keep the screw clear. Having canted the bow out slightly, go ahead slow, and as she moves out from the dock give her as much port helm as she will stand without swinging the stern in too far. In this way work her up along the dock, canting her out more and more. In the meantime, a line is run from the *starboard* quarter but well forward toward the midship point. This must be carefully attended to keep it clear of the screw. When she has turned out sufficiently to give this line a clear lead, it is held on and acts as a spring. Going ahead on the engines with rudder hard right[1] will now turn her head rapidly, and she may be worked around and into place without much difficulty. The fact that the spring is made fast near the midship point, gives a good leverage for the steering effect of the rudder, whichever way it is put.

If the starboard side is to the dock and it is proposed to wind her, it may be better to back around, as the effect of the screw (right handed) will be to throw the stern out and to turn her as is desired. In this case, take a line around the bow to the port side a little forward of the midship point. Leave this slack in the beginning. Go ahead on a starboard bow spring until the stern is canted out slightly, then back with rudder hard left,[2] holding on to the port bow line. The stern will swing around rapidly, the spring holding her up and in. When she is nearly around she may be worked in at any point desired by going ahead or backing on the engines, using the helm to steer her to her place.

It is frequently necessary to wind a vessel in making a landing. Say the tide is fair and the dock to starboard, that it is desired to put the port side in, and that there is not room to run beyond the pier and turn (Fig. 1, Plate 145). Make as much of a sweep as space permits, putting the bow in near the place where it is to be, and run a line from the port side a little forward of the midship point. Back slow with helm hard a-starboard and let her swing on the line. When she is nearly around, she may be steered into place by going ahead on the engines and using the helm.

If the tide is running out and it is desired to turn, the conditions being otherwise identical with those of the preceding case,

[1] Helm hard aport. [2] Helm hard a-starboard.

Fig. 1

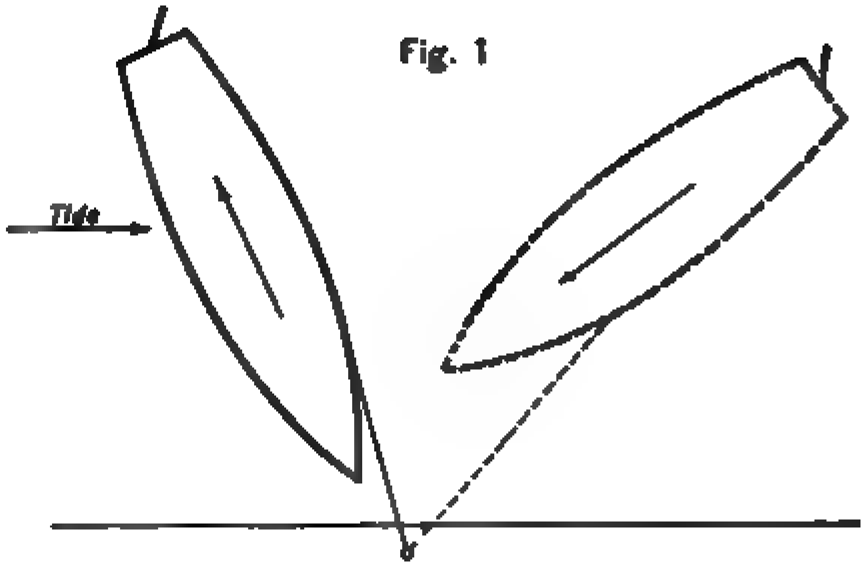


Fig. 2

Fig. 3

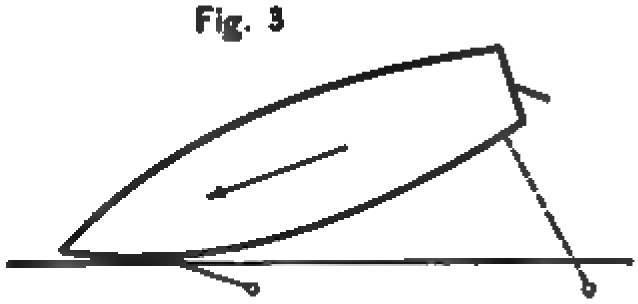


Fig. 4

Fig. 5

HANDLING STEAMERS AROUND

run up to the other end of the berth and get out a line from the port side a little abaft the midship point, taking it around the stern and keeping the bight up clear of the screw. Go ahead with left rudder[1] and she will turn on the spring and work into place (Fig. 2, Plate 145).

It is possible to wind a small steamer by putting her stem against the dock and going ahead with helm hard over to the side which will throw the stern out and swing it around. A large steamer handled in this way would probably cut through the dock.

Freight and passenger steamers frequently have to hold their bows in against the dock for discharging cargo from the forward deck. In such cases they use a spring as in Fig. 3, Plate 145, and keep their engines turning slowly ahead with the helm hard over to the side which will throw the stern off. A steamer will lie this way for an indefinite length of time even though the tide may be ahead. If the tide is aft, a stern line is used to assist in holding her.

GETTING CLEAR OF A DOCK.

In preparing to get clear of the dock, all lines should be singled, and as many as can be spared got out of the way; all permanent fasts let go and hauled to the dock, spur-shores cleared away, and men stationed by the line which will be the last cast off.

It is convenient to select a time when a feeble current is running along the face of the dock, to set the bow or stern out (the line at the other end being kept fast), thus getting a cant for working out, either ahead or astern. In the absence of such a current, advantage may be taken of a breeze setting off from the dock, or the bow may be swung in more or less by going ahead slow on a bow line with helm hard over to the off-shore side. She may then be backed off clear.

Care should be taken in all cases, but especially with twin-screws, to keep the screw clear of the dock.

With a current or a fresh breeze setting onto the dock, it will be necessary to provide some means of hauling out, and for this purpose a tug is most convenient, unless it happens that a line

[1] Starboard helm.

can be run to a buoy or to a neighboring dock. If an anchor has been dropped in coming alongside, it will of course be useful now. In the absence of any other means, a stream anchor may be laid out without much trouble.

It is sometimes necessary to get clear of a dock where the current always runs strongly in one direction, as in a river. Officers having this to do as a part of their regular business become very expert at it. A case in point is the Peiho River, at Tientsin. The river is only just wide enough for the steamers trading there to swing from shore to shore, and the tide runs four or five knots and never slacks. Steamers lie alongside with head up stream, port side to dock, and when ready to turn for going out, having a full head of steam, they cast off all but a line from the starboard (off-shore) quarter, and swing out into the stream. The bow sweeps around with great rapidity athwart the current, and down the stream. At just the right instant, while heading three or four points across and down, the starboard quarter line is cast off and the engines started full speed ahead with helm hard over.

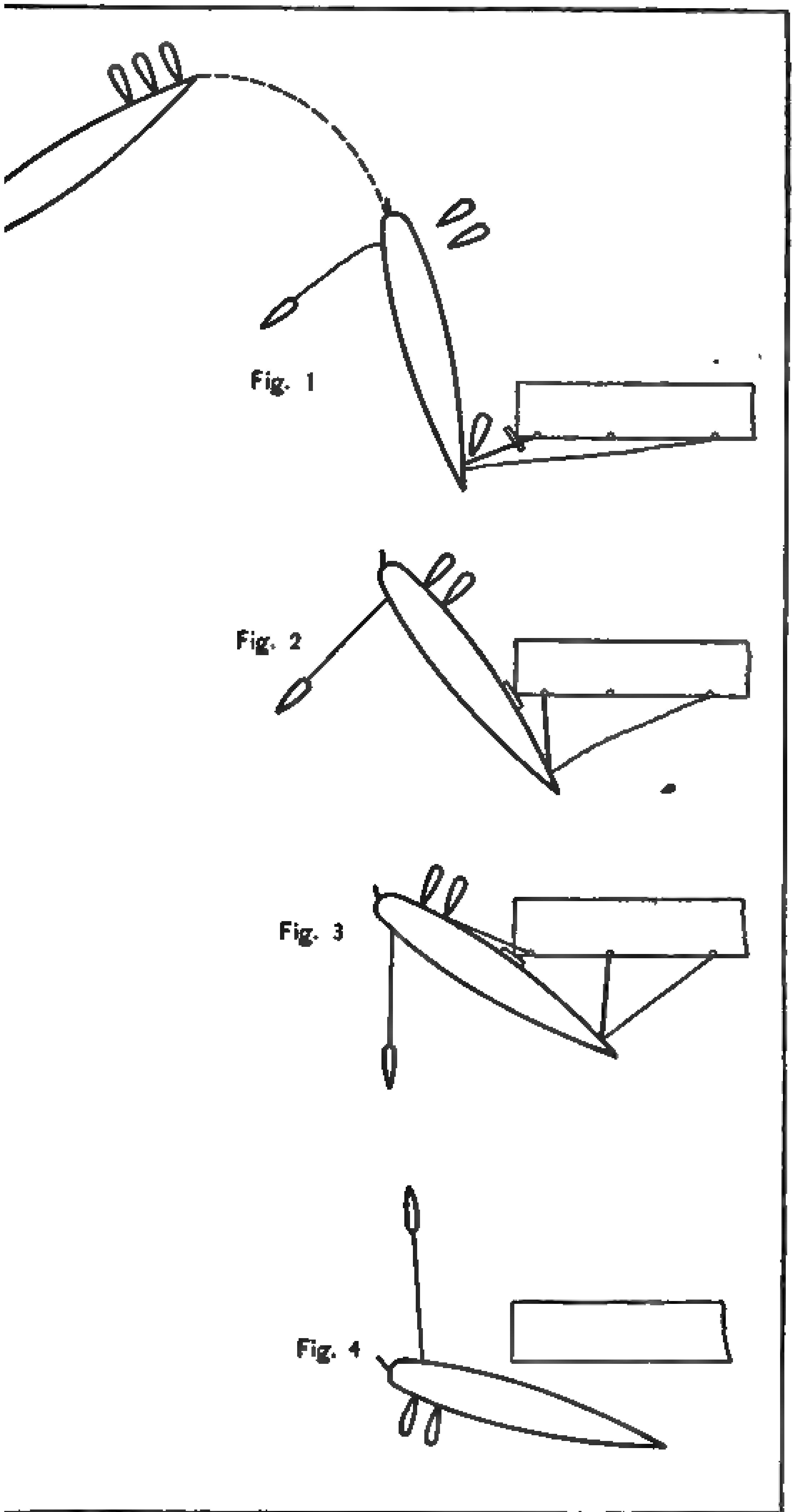
§ IV. HANDLING A LARGE VESSEL WITH THE AID OF TUGS.

In some cases tugs are used for actually towing the larger vessels; in others, merely for turning them, holding them up against the tide, etc.

A tug having to tow a large vessel in docking is usually placed on the quarter which will be away from the dock, with a line for going ahead and another for backing, both of which are taken from the *bow* of the tug to some convenient point on the other vessel. A breast line is also run from the stern of the tug to prevent her from swinging off (Figs. 4 and 5, Plate **145**). A tug placed like this is favorably situated for turning to either side by going ahead or backing.

In some cases it is found convenient to place a tug on the off-shore bow. This is in case the vessel must be brought to the pier with a considerable cant inward. The tug on the bow is well placed for bringing her in like this and for hauling the bow out at the last moment while the stern is being worked in.

In docking large ocean liners, a number of tugs (frequently as many as six) are used for turning the vessels and for holding



DOCKING A LARGE STEAMER.

them against the tide as they work into their slips; but such headway or sternway as is needed is generally given by the engines of the vessels themselves.

In this, as in all other cases of working around a dock, much use is made of the helm; and if the vessel has twin-screws, these are used also, in connection with the tugs, for turning her.

The tugs may take lines from the bow or quarter, or they may point their stem-fenders against the side, and push. Spring and check lines are used as in the cases already described, but are not trusted to the same extent for checking the vessel or for springing her around. They must be large and very carefully attended. If allowed to lead fore and aft or nearly so, they will almost inevitably carry away as the ship forges ahead upon them. They should therefore be frequently shifted as she moves along the dock, being kept approximately at right angles to the side.

The following description of berthing a large Atlantic liner on the New York side of the North River is contributed by an officer of many years' experience in such work. As the tide is running flood (to the northward) the ship is berthed on the south side of the pier (see Plate 146).

> On the flood tide, the ship comes up the river on the Jersey side and is turned completely around, above the pier, by the aid of tugs which are placed with their fenders against the port bow (Fig. 1, Plate 146). After the ship is turned nearly parallel with the tide or with the trend of the river, one tug is usually kept alongside on the port bow, in case the ship's head should require to be canted to starboard, the other tugs backing away ready to be placed on the port quarter. As soon as the ship is near enough to her pier, heaving lines are sent off to her by a small rowboat and by means of these the bow-lines are run. These lines are led some distance up the slip. Another heaving line is carried to the ship and a hauling line of about 3" manila is sent from the ship to the pier, where it is made fast with a long bowline through the eye of an 11" manila hawser which is faked on the end of the pier, near the southeast corner. When ready, the 3" rope is taken through a forward pipe to one of the ship's winches, the hawser hove on board and the eye hove over the bitts. This line is for helping to slew her around into the slip. The ship is then allowed to go as far ahead as possible before the strain is permitted to come on the spring (Fig. 2, Plate 146). Great care must be taken that the ship does not get too much of a cant towards the pier, with the tide too broad on the starboard bow, as it is most important that these heavy vessels should not be permitted to approach the corner of the pier sideways at any great rate of speed, but gradually. We have had instances of ships taking the corner of the pier

with apparently only a moderate force and denting plates and bending frames to such a degree that it was a question of thousands of dollars to place the hull of the ship in its original condition. We use for a fender a spruce built log, about 40 feet long by 30" by 24". This log is fitted with chains and ropes so that it can be handled from the pier and placed in any position required. It is laid across the corner of the pier for the ship to land on at the water line, so that instead of one or two of the ship's frames taking the pier, she is landed on a dozen or more. As soon as the ship takes the fender, signal is given to the tugs and they commence to push her port quarter out into the stream. One tug is usually placed on the starboard quarter attached to a hawser, while two or more push on the port quarter. With a twin-screw ship it is necessary to have at least this one tug on the starboard quarter to prevent her quarter from taking the corner of the pier with a flood tide running, endangering fouling the port propeller. The bow ropes by this time are passed some 150 or 200 feet up the pier. When all is ready, the signal is given to the bridge, starboard engine "Slow Ahead," rudder left.[1] The ship gradually swings toward a line at right angles with the trend of the river with her bow pointing into the slip. As she comes around, the *check* is slacked away to permit her to go ahead, and bow-lines are shifted as required (Fig. 3, plate 146).

The after ropes are run by the small rowboats, sometimes by tugs, as soon as her quarter nears the end of the pier. As she moves into her berth, the bow and stern lines are kept as nearly abreast as possible, by short fleets, and the ship's stern kept as close to the pier as is prudent, always taking into consideration the care that must be observed not to foul the port propeller. The engines can move the ship ahead or astern as much as necessary. There is a 12" check rope on the pier near the berth, ready to be hauled on board into one of the after chocks on the lower deck. There is also a wire pennant passed out from one of the chocks from the lower or spar deck, with an eye, in which is to be hooked the block of a threefold purchase block leading from the pier.

When she has sufficient way to reach her berth, she is placed in proper position by lines and tackles which are entirely in the hands of the shore gang on the pier.

The warps used on these vessels are 7" and 8". The lines themselves must never be passed forward from the stern chocks, but heaving lines used when it is necessary to pass forward any distance away from the quarter, as great care must be taken that these warps are not allowed to foul the propellers. In handling the check from the end of the pier, the shore end should be fleeted as often as possible as the ship goes ahead, in order that the strain may not be brought too much fore and aft. Of course the nearer the check is kept at right angles with the line of the ship, the less strain will be required on it to cant the ship's head, and when it is nearly fore and aft almost the slightest way on the ship will carry it away, unless the greatest care is observed.

[1] Helm a-starboard.

Leaving the Slip.

We undock these ships from both north and south side of the pier at any stage of tide.

When undocking from south side of the pier, with tide running strong ebb, an 11″ line is taken from the port quarter to one of the largest tugs (Fig. 4, Plate 146). Extra men are placed on the tug to assist in handling this rope. Two or three moments before the sailing time, the tug starts ahead to the northward and pays out perhaps 75 or 80 fathoms of scope. As the stern of the ship is about 100 feet inside the end of the pier, this hawser is rove through a thimble spliced into a 4 tail rope. This slip rope is taken around the post at the south corner of the pier with three or four turns, and the end held by some of the shore gang, to prevent the bight of the hawser from flying into the crowd that is usually on the dock at sailing time. When the ship is far enough astern for the bight of the hawser to clear the corner of the pier, the slip rope is let go. The end of the hawser attached to the ship is fitted with a lashing eye (old cargo falls are used for the lashings) and the eye hove over one of the bitts. When the ship is turned head to the southward, this lashing, at a signal from the bridge, is cut on the ship; the eye of course flies clear of the vessel and prevents any danger of fouling the propeller. In addition, one or two tugs are used to push on the starboard quarter. As soon as the ship is partly out of the slip these tugs let go the quarter and proceed to the port bow. With the aid of the tugs on the port bow and the one attached to the hawser, the ship of course is swung with her head to the southward, and when far enough around the tugs are let go and ship proceeds.

With the flood tide, two or three tugs are ready to put their stems against the port quarter of the ship. As soon as the propeller is well clear of the pier these tugs are to ease the ship off the corner as much as possible. For sliding out we have a built spar, 50 or 60 feet long by 20″ by 24″. This spar is slung abreast of a plate on the ship's side that is clear of sidelights and coal ports, and is secured firmly to the pier by chains and heavy ropes. The outer side of the spar is sheathed with 2″ spruce that can be easily replaced as it becomes broken or splintered.

For handling a large liner when her own engines are not available, at least six tugs would be used; one on each bow (ahead) one on each quarter alongside and one on each quarter with a single line. The tugs alongside are especially for stopping the vessel's way when necessary, though of course they assist also in moving her ahead and in turning.

Turning a Vessel While Towing Alongside.

A tug towing a vessel alongside sometimes has occasion to "*wind*" the tow for putting her alongside in a particular way, or for getting on the off side in landing, to avoid being jammed between the tow and the dock. Plate **140**.

The tug first gives the tow a sheer with the helm (Fig. 3). She then backs, slacking all lines except the backing line (Fig. 4), then, a little later, slacks everything and puts her stem against the stern of the tow and goes ahead, pushing the stern around (Fig. 5); and ends by making fast alongside with her bow toward the stern of the tow (Fig. 6), and with her own port side to the tow instead of the starboard side as in the beginning. This manœuvre may be seen every day in New York harbor, where tugs handling scows have to get on the *off side* of the scows for landing the scows alongside while themselves keeping clear.

CHAPTER XVIII.

PLACING A SHIP IN DRY DOCK.

The operation of safely placing a ship in dry dock, safely supporting her with blocks and shores, and afterwards floating her out of dock, is so common that the care and experience necessary to ensure success in this operation are not generally understood, yet it is possible that very serious damage may occur during the operation, if intelligent supervision be neglected.

Every ship should carry a docking plan which shows: the length on the load water line; the length over all; the location of all the under water valves; the locations of the water-tight bulkheads, the engines, the boilers, the turrets (if any), and such other weights and fittings as are peculiar to any particular ship; the length of straight keel, together with dimensions locating accurately the cut-up (if any) of the dead wood aft, together with any peculiarities of the stern post and rudder; also such dimensions as will show the curvature of the forefoot, especial care being taken to locate the exact point where this curvature departs from the straight line of the keel. The docking plan of a battleship is shown on Plate **147**. The docking plan should also contain information as to cross-sections amidships and elsewhere, showing the beam at or near the water-line, the shape and location of the keel, the docking keels and bilge keels, the struts, the propellers and all other objects below the water-line; in other words, the docking plan must furnish all necessary information concerning the under-water hull and its accessories, also dimensions as to projections above the water-line which increase the nominal beam of the vessel: the latter information is frequently of extreme value in foreign ports whose docks have their dimensions tabulated with reference to merchant vessels only.

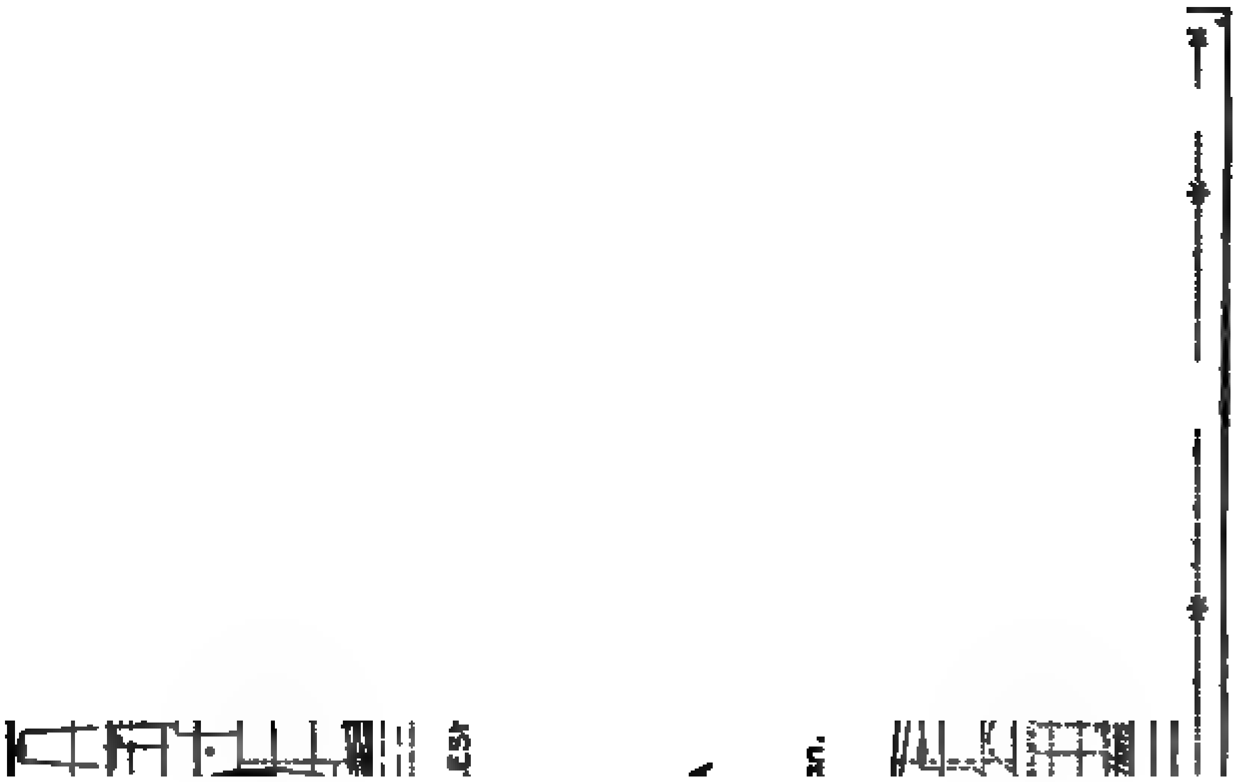
In our navy yards, blue-prints of such plans are usually in the possession of the Naval Constructor—elsewhere it is necessary to furnish such plans to the responsible authorities of public or private docks—without them, the efficiency and safety of the docking are absolutely dependent upon the skill and experience of those having control of the docks.

The dock master of any particular dock being given the docking plan of a ship to be placed therein, proceeds as follows: knowing the ship's draught, the maximum depth over the sill, together with the current and tidal variations in the vicinity, he decides upon the time the vessel should enter the dock, and so informs the commanding officer, who thereupon makes the necessary arrangements to ensure that the vessel at the time specified shall be absolutely upright, without any list either to starboard or port.

The entrance to a dry dock may be closed by hinged gates, a floating caisson, or a sliding caisson; the first and last methods are often used in foreign docks, but in home docks, a floating caisson is most commonly found; it usually has a ship-shape form with sufficient stability to safely float upright when empty; to sink it, valves are opened which admit water to its interior, and to raise it, all outboard valves are closed and the water it contains is pumped overboard.

The dock floor carries along its center a line of blocks, called "keel blocks." These are usually of wood and are secured to the dock floor in various ways. Their distance apart varies in different docks, but it is customary to place these keel blocks much closer together under turrets and other heavy local weights on war ships, than is done with ordinary vessels. Those ships having straight keels, but whose fore-foot is cut away, are supported forward by building up the corresponding keel blocks to suit the contour shown on the docking plan. With ships having docking keels, a double line of keel blocks is provided, running parallel to the center line and at the proper distance therefrom, given on the docking plan. At intervals along the bottom of the dock and at right angles to the center line, are the bilge ways, along which slide the bilge blocks which can be moved towards or away from the center line by the hauling lines which are manipulated from the dock coping. Each bilge block is built up of a proper height and level, as determined from the docking plan, so that after the vessel's keel rests upon the keel blocks, the bilge blocks can be hauled and accurately fit against the bottom, thus thoroughly supporting the ship before the water has been pumped out of the dock. Care is taken that the bilge blocks are not hauled so that they will bear against an under-water valve or other accessory which would be injured by heavy local pressure. In foreign docks, bilge blocks are rarely used, shores being fitted to sustain the bottom after the dock is empty.

Plate No. 147.



To maintain the vessel upright after she has grounded on the keel blocks, and before the bilge blocks are hauled, wale shores are used, one end resting against the ship's side, the other against the dock's side, wedges being used to set them taut. These shores are prepared of the desired length and placed in the vicinity of their final location by means of information obtained from the docking plan. Certain marks are also made on the coping which will accurately locate the ship's position in the dock, in order to ensure that as the water is pumped out, the under-water hull shall exactly coincide at the proper time with the various blocks and shores which have been made ready to receive it. Plate **147** shows the plan which would be prepared for a particular dock after receiving the docking plan of the vessel which was to be placed therein.

These preparations being completed, water is admitted, the caisson is floated and removed, and the dock is then ready to receive the ship. After the ship's bow has safely entered the mouth of the dock, the responsibility for her safety rests upon the dock master; the methods of securing this safe entrance are considered elsewhere. The dock master then hauls the ship into the dock until certain definite objects near her bow and stern coincide with the marks which he has laid out upon the dock coping in accordance with the docking plan. The caisson is then placed in position, the pumps which empty the dock are started; their operation between this time and the time of the complete emptying of the dock being controlled by the judgment of the dock master.

In the meantime the necessary arrangements have been made to ensure the ship being safely centered in the fore and aft and athwartship directions, and the wale shores have been floated and placed approximately in their proper positions: during this period, by the use of sighting battens or other means, the variations of the ship from the upright are finally determined, and the necessary measures are taken to correct any listing to starboard or to port.

Under ordinary circumstances, the ship's keel first touches on the keel blocks aft, and with a ship having a large amount of drag, special precautions are necessary to prevent listing, because, under these circumstances, stability is lessened very rapidly. The grounding of the keel aft upon the keel blocks is indicated in various ways, but before this occurs, the dock master has ar-

ranged the wale shores so that any inclination towards listing or twisting shall be prevented as far as possible. The entire line of wale shores is not set up tightly until the forward portion of the keel is bearing upon the keel blocks prepared to receive it. As the water level within the dock becomes still lower, the bilge blocks are hauled, and the ship during the remaining period of her stay in dock is supported by the keel blocks, bilge blocks, and shores.

After the dock is emptied, the ship's bottom is thoroughly cleaned and careful examination is made of the entire bottom as regards fouling, corrosion and damage. All outboard valves, propeller struts, propellers, shaft bearings, rudder pintals and gudgeons, strake edges, butts, etc., are carefully examined. It is usually necessary to re-grind the underwater valves, and to re-pack the stuffing boxes of valves and of the rudder; if the plating butts show lines of rust, they should be re-calked; if the rivet heads show serious corrosion, the rivets should be removed and new ones driven; if there is serious corrosion or pitting, the plating should be thoroughly cleaned and brushed before re-painting; in cleaning the bottom from fouling substances, care should be taken that the paint underneath is disturbed as little as possible; zinc rings and zinc plates at the openings of outboard valves, and in the vicinity of the propellers, should be renewed if their corrosion shows galvanic action. The bottom is then given fresh coats of anti-corrosive and anti-fouling compositions, which should be applied whenever possible, on dry surfaces.

If special repairs have been anticipated or are found to be necessary after the dock is empty, the necessary action is taken immediately, because the length of time a ship remains in dock must be reduced to the minimum.

The particular precautions which must be taken in docking ships which are not in ordinary condition, must depend upon the judgment of the dock master.

During the period that a ship is in dock, no change of any kind in the distribution of her weights should be made without the knowledge and consent of the dock master, because the ship when being floated might suddenly change her trim so as to cause serious damage to herself or to the dock.

The painting of the bottom, and all under-water repairs being completed, a time for flooding the dock is agreed upon by the commanding officer and the dock master. The former stations

men at the outboard valves and elsewhere, as he deems proper to ensure that water does not enter the ship, and the latter stations men at the various shores and lines and elsewhere, to prevent as far as possible, any injury to dock or ship, from a change of weights or an unexpected alteration in tide or wind.

The water in the dock enters continuously under the dock master's control. When it has risen to a sufficient height, the bow ordinarily first lifts from the keel blocks, and shortly afterwards the stern. If there has been any material change of weights while the ship has been in dock, she will suddenly and violently take a list to starboard or to port, with consequent damage to herself and the dock.

The ship being safely afloat, the water is allowed free entrance until the level within the dock coincides with that outside, after which time the caisson is floated as quickly as possible, then removed, and the ship is floated out of dock.

CHAPTER XIX.

WEATHER AND THE LAWS OF STORMS.

§ I. WEATHER, WINDS, CLOUDS, RAINFALL.

The subject of weather may conveniently be studied in its general features by reference to a map showing normal or average conditions at different seasons of the year. Plate **148** gives such a map, showing normal winds, barometer pressures, and temperatures, for January and July, throughout the world with the exception of the extreme polar regions. The curves in black are "isobars" or lines of equal barometric pressure. It will be seen that these lines are, in the main, closed curves about areas of high or low barometer;—the distinction between a "High" and a "Low," as these areas are called, depending not upon the actual height of the barometer, but upon the way in which the wind circulates about the area; or, more accurately, upon whether the characteristic pressure is the result of descending or of ascending currents. It is clear that a high pressure is the natural accompaniment of descending currents of heavy air, and vice-versa; but whereas a barometric height of 30 inches may indicate a rising current at one place and time—which would make it a Low;—it may indicate a descending current at another place and time, and may thus be a High. It tends to clearness, therefore, to use, instead of "high" and "low," the terms "anti-cyclone" and "cyclone," which define the wind circulation instead of the pressure resulting from this circulation. As thus used, the term cyclone has no necessary connection with a gale. It defines simply a condition of affairs in which an ascending current of air at a more or less clearly marked central area is surrounded by an inflowing spiral whirl which may or may not take on the concentrated and intense character with which we commonly associate the term cyclone. Similarly "anti-cyclone" defines a condition of affairs in which a descending current of air develops into an outward flowing spiral whirl with a motion of rotation opposed to that of the cyclone (Plate **149**). Both of these phenomena will be more fully described hereafter.

The relative positions of the warm red and cold blue tints

on Plate **148** show January as winter in the northern and summer in the southern hemisphere; and July as summer in the northern and winter in the southern hemisphere. The bounding lines of the red and blue tints are the isotherms (lines of equal temperature) of 70° F. and 30° F. respectively. It will be noted that the thermal equator—as the middle of the equatorial hot belt may be called—does not coincide with the geographical equator, but fluctuates in a way which is evidently influenced by the seasons, continents, oceans, and winds.

When air is heated, it expands and becomes lighter; it therefore rises, and the ascending currents cause a decrease of pressure. Another important result follows in the formation of clouds and rain due to the presence of aqueous vapor in the ascending current. As the air rises it expands more and more, cooling at the same time through the absorption of heat due to this expansion, while it is still further chilled by the lower temperature of the upper regions of the atmosphere. As a consequence of the reduction in temperature, much of the aqueous vapor is condensed into clouds or precipitated in rain, giving off a large amount of heat, which tends to rarefy the air still further and so to intensify the upward draft.

We have here, briefly outlined, an explanation of the weather characteristics, which in some degree mark all regions of low barometer and cyclonic circulation, whether these extend over thousands of miles of ocean and continent as in the cases shown on Plate **148**, or are localized in the narrower and more intense form of tropical hurricanes. The weather of all such regions is characterized by more or less cloudiness, frequently accompanied by rain, by low barometer, and by winds which, while not necessarily violent, are usually stronger than in an anti-cyclone, since the determining cause of these winds—an upward rush of warm air with the attendant features that have been described—naturally takes on a somewhat more violent form than does the downward current of cool and heavy air which is the determining cause of anti-cyclonic circulation.

The velocity of the wind, as well as its direction, depends upon relative pressures in adjoining areas; being determined by the steepness of the "barometric gradient," or the amount of difference in the reading of the barometer for a given distance. This is well illustrated in the cyclone and anti-cyclone of Plate **149**, in which the distance between the successive iso-

WINDS AND WEATHER FOR JANUARY AND JULY.

WINDS AND WEATHER FOR JANUARY AND JULY.

bars indicates the steepness of the barometric gradient. Where the isobars are crowded closely together, the change in pressure is very great for a small change in position; or in other words the gradient is very steep. At such places the velocity of the wind is high. Where the isobars are separated more widely, they indicate a gradual change in pressure or a gradual slope to the gradient, and here the winds are more moderate.

To compare barometric gradients, they are commonly reduced to hundredths-of-an-inch per 15 sea miles. On this scale the steepest gradient ever observed was in the cyclone that passed over False Point, India, in September, 1885. This gradient was 238; which means that in a distance of 15 miles, there existed a difference in barometric reading of $2\frac{38}{100}$ inches.

It will be observed in Plate **149**, that the wind blows partly across and partly along the isobars, forming the spiral whirl which has been elsewhere described.

The following description and explanation of a sudden shift of wind over the North Atlantic Ocean is from the Pilot Chart of the U. S. Hydrographic Office for July, 1900 (Plate **150**).

It illustrates in a very striking way the relation between the direction of the wind and the barometric pressure.

During the course of March 17, 18 and 19 last, the steamers along that portion of the transatlantic routes lying to the eastward of the meridian of 60° experienced a sudden shift of the wind from S.E. to N.W., accompanied by a marked increase in force, as indicated by the following table. The shift progressed steadily eastward, the date and hour at which it was noted aboard the several steamers distributed along the lane depending upon the position of the various vessels at the time, becoming successively later as the longitude diminished.

Vessel.	Date.	Long., West.	REMARKS.
Nederland..	Mar. 17	61° 35′	Strong to fresh breeze (from the South); at 8 a. m. wind shifted suddenly to NW.
Maryland...	Mar. 17	57 42	Southerly wind until midnight, when wind veered to NW. strong.
Minnesota.	Mar. 17	56 29	Southerly wind shifting at midnight to NW.; moderate gale.
Turcoman..	Mar. 18	51 27	At 3 p. m. wind shifted suddenly from South to N NW. and blew a moderate gale.
Anchoria...	Mar. 18	50 42	Wind SE.; at 5 p. m. wind hauled to W SW., later to NW.
Chester.....	Mar. 18	48 53	At 11 p. m. wind shifted (from S SE.) to NW., moderate gale.
Mokta......	Mar. 19	48 22	At 2 a. m. wind shifted from S SE. to N NW.
Hekla	Mar. 19	46 47	Wind S SE., 2, until 5 a. m., when it shifted through SW., West, to NW., 8.
British King	Mar. 19	46 00	At 8 a. m. wind shifted from SE. to NW.
Euxinia.....	Mar. 19	44 52	At noon wind suddenly shifted from SE. 5, to N NW., 6.
Symra	Mar. 19	44 04	Wind from South; at 1 p. m. wind changed to W NW.
Helios	Mar. 19	42 10	At 8 p. m. wind changed (from SE.) to N NW.

Diverging according to Ferrel's Law
to form a Cyclonic Whirl.

Fig. 3

From "Storms, Storm-tracks and Weather Forecasting"
Published by the U. S. Weather Bureau.

Storm Tracks for August.

ms noted during 10 years are grouped according to their places of origin,
figures opposite the brackets indicating the number for each group.

STORMS AND STORM TRACKS.

The meteorological conditions prevailing throughout this part of the North Atlantic at Greenwich mean noon of March 19 are shown upon the chart (Plate 150), where the symbols have the usual significance—the center of the arrow head marking the position of the observing vessel at the time of observation, the arrows flying with the wind, the number of feathers indicating the force of the wind, etc., etc. An inspection of the chart shows that the sudden shift of the wind (which several observers in their extended remarks stated was not announced by any decisive variation of the barometer, the mercury standing above 30 inches throughout) was due to the passage of the observing vessel across the shallow trough of low pressure which intervened between the two areas of high, each of these latter areas being surrounded by a well-developed system of anti-cyclonic winds, the light southerly and southeasterly winds proper to the rear of the preceding area being almost instantaneously supplanted by the strong northerly and northwesterly winds proper to the front of the following area. For the purpose of distinctness the outline of the trough is indicated by cross-hatching.

The several heavy dotted lines join the points at which the shift occurred at the same hour, the latter being indicated in the diagram. Thus along the entire length of the most western of these lines the shift was noted at 8.00 A. M. of March 18; along the next at 8.00 P. M. of March 18, and similarly for the others. Comparing the distance intervening between these lines it is seen to be in the neighborhood of three degrees of latitude or 180 nautical miles, giving for the eastward progress of the shift an average velocity of 15 miles per hour.

The indrawing air of the cyclone obtains its moisture by evaporation from the sea and from damp earth, or from areas of ice and snow if it passes over such. Its capacity for holding moisture in invisible suspension increases with the temperature; and for a given quantity of moisture so held, there is a perfectly definite temperature, called the "saturation point" or "dew point," below which the air cannot be cooled without giving out some part of its moisture in the form of cloud or rain. As already explained, this is why the warm moist currents from the surface of the earth, as they rise into the cooler regions of the upper atmosphere, produce the clouds and rainfall of cyclonic weather. It is the reason also, for the comparatively clear skies and dry weather of anti-cyclonic regions; since the cool dry air flowing from the higher regions downward and outward has its temperature raised and is enabled to take up into invisible suspension much of the moisture that it encounters, thus producing a comparatively dry atmosphere and clear skies. Naturally the farther we move from the center of circulation, whether cyclonic or anti-cyclonic, the less

marked these characteristics become. They may, moreover, be modified in many ways by local conditions of the land or sea over which they extend or over which they have passed; for all the features which would mark the weather of an ideal globe of uniform surface are modified in countless ways by the unequal distribution of land and water, and the varying physical features of both;—by currents, icebergs, etc., in the oceans; and by deserts, mountain ranges, and areas of forest or clearing on the land.

Thus the warm moist air over the Gulf Stream is chilled and turned into fog by contact with the cold Labrador Current off the Banks of Newfoundland. Similarly the southwest monsoon, charged with vapor from the tropical latitudes of the Indian Ocean, coming in contact with the cold heights of the Himalayas, precipitates its moisture in torrents of rain on the southern slopes of those mountains and passes on over the plains to the northward as dry as if it came from a desert. The proximity of a mountain range has always an important influence upon climate and weather.

GENERAL WIND CIRCULATION.

It would be natural to expect that in the great equatorial hot-belt, the phenomena of expansion from heat, of ascending currents with resulting low barometer, of condensation and precipitation of moisture, would be more frequent and more marked than elsewhere. Such is in fact the case; and Plate **148** shows clearly the great systems of steady indrawing Trades that meet in the region of equatorial rains and calms, and the connection of these with the great and generally permanent areas of high and low barometer that have been referred to as largely determining the circulation of the atmosphere about the globe.

As the Trades approach the equator there are constant little rising currents marked by the characteristic trade wind clouds; and in the region of permanent low pressure, calms, clouds and rain, which we have called the equatorial belt, but which is commonly known as the "Doldrums," they meet and rise, generally quietly and steadily but sometimes in the great eddies or whirlwinds with which we are familiar as tropical cyclones.

The tendency of the trades toward the equator from the north and south results naturally enough from the conditions which

have been described as prevailing in the equatorial belt; but explanation is required of the westward component in these winds, as well as of the unvarying regularity with which the winds of cyclones turn always in one direction in the northern hemisphere and in the opposite direction in the southern, while for anti-cyclones these directions are reversed.

The theory which is commonly accepted accounts for all of these phenomena by the rotation of the earth.

As the earth revolves from west to east the envelope of air surrounding it shares its motion, but may in addition have a motion of its own. If we imagine a particle of air moving from some point in north latitude toward the equator, it is clear that the particle will in the beginning have an eastward velocity equal to that of the spot from which it starts; but that as it moves toward the equator it will find the earth beneath it turning more and more rapidly (in linear velocity) and, failing to take up entirely this increased velocity, will lag behind and manifest itself as a wind from the northward and eastward. That is to say, it will be continually diverted to the right as it moves southward.

A particle of air moving from the equator northward, will, on the other hand, start out with the eastward velocity of the earth at the equator, and will thus outrun the more slowly moving surface over which it passes as it travels northward. Thus this particle will also be diverted to the right. And so with every particle of air which we may suppose to be moving in the northern hemisphere along any line except one due east and west. To some extent it will have a tendency to turn to the right. In Plate **150** are shown a number of such particles moving toward a common center of low barometric pressure, and forming inevitably a left-handed swirl (Fig. 2).

Similar considerations will make it clear why the winds flowing outward from a "high" revolve in the opposite direction, and why all these conditions are reversed in southern latitudes.

The following simple law, first enunciated by Buys-Ballot, puts in convenient form the relation between pressure and wind circulation.

When facing the wind, in the northern hemisphere the pressure is lower on your right hand and higher on your left; and conversely, in the southern hemisphere, it is higher on the right and lower on the left. This rule, it should be noted. applies to winds in general; not alone to storms.

Observations of winds, temperatures and pressures extending over a long period of years indicate the existence in the polar regions of an area of low barometer about which the winds circulate with the characteristic cyclonic direction, giving rise to the "Westerlies" or "Passage Winds" of the regions north and south of the Trades.

It is clear, of course, that this condition cannot be due to the causes which produce the low pressure in the equatorial region; and the commonly accepted theory accounts for it as a result of the centrifugal force acting upon the mass of the atmosphere as it is whirled about by the earth's rotation on its axis. Whether this be the true explanation or not, there is abundant evidence that the pressure is low at the poles as well as at the equator and that there exists an intermediate belt of generally high pressure in the neighborhood of 30° of latitude, from which the air tends to draw—on the one hand toward the equator, on the other toward the poles. This belt of high pressure, of comparative calms, and of baffling winds, while not always well marked over the continents, can be clearly traced across the ocean, where it is well known to navigators under the name of the "Horse Latitudes."

The winds blowing about and toward the poles take up the characteristic motion which has been explained, and there results, in latitudes above (approximately) 35° north and south, a steady flow of the atmosphere toward the east. At the earth's surface, this flow is often delayed, arrested, and turned back to the westward by local and temporary causes, but in the upper regions of the atmosphere it continues without interruption though not with unvarying velocity.

In this continued eastward movement of the air is to be found the key to the fluctuations of weather which (for example) sweep across the continent of North America and the North Atlantic Ocean; as well as the possibility of predicting from day to day approximately what weather may be expected at any given place. Disturbances of the atmosphere—highs and lows, with the weather features which have been described as characterizing them—sweep across the continent in a regular procession, following paths which may vary considerably, but are always toward the eastward. These disturbances may originate within the limits of the continent or may enter it from the Pacific; but they invariably leave it by the Atlantic sea-

board and usually by way of the New England coast or the Gulf of St. Lawrence (see Plate 150). An examination of the weather maps published by the United States Government for several successive days gives an interesting view of this progression of varying weather characteristics toward the east, and makes clear in a general way the laws upon which weather forecasting is based. Plate 151 shows a map of this kind. The corresponding map for the following day would show the successive highs and lows as having moved to the eastward, carrying with them their characteristic features of wind-circulation, temperature, cloud or clear sky, precipitation, etc.

The following description of the daily weather map is from a leaflet published by the Weather Bureau:

This map presents an outline of the United States and Canada, showing the stations where weather observations are taken daily at 8 A. M. and 8 P. M., seventy-fifth meridian time. These observations consist of readings of the barometer, thermometer (dry and wet), direction and velocity of wind, state of weather, amount, kind and direction of the clouds, and amount of rain or snow; they are telegraphed to Washington and to many of the Weather Bureau stations throughout the country for publication on the maps. Solid lines, called isobars, are drawn through points having the same atmospheric pressure; a separate line being drawn for each difference of one-tenth of an inch in the height of the barometer. Dotted lines, called isotherms, connecting places having the same temperature, are drawn for each ten degrees of the thermometer. Heavy dotted lines, inclosing areas where a decided change in temperature has occurred within the last twenty-four hours, are sometimes added. The direction of the wind is indicated by an arrow flying with the wind, or opposite to the ordinary vane. The state of weather—whether clear, partly cloudy, cloudy, raining, or snowing—is indicated by the circular symbol. Shaded areas, when used, show where rain or snow has fallen since the last observation.

The general movement of storms in the United States is from west to east, similar to a series of atmospheric waves, of which the crests are designated on the map " Highs," and the troughs or depressions " Lows." These alternating Highs and Lows have an average easterly movement of about 600 miles per day.

High winds, with rain or snow, usually precede the Low area, often extending to a distance of 600 miles to the eastward of the center of the storm. In advance of the Low the winds are generally southerly, and consequently bring high temperature. When the center of the Low passes to the east of a place, the wind at once shifts to the west or northwest, bringing lower temperature. The temperature on a given parallel west of the Low may be reasonably looked for on the same parallel to the east when the Low has passed, and frost will occur along and north of an isotherm of about 40°, if the night is clear and there is but little

wind. Following the Low usually comes an area of High, bringing sunshiny weather, which in its turn is followed by another Low.

By bearing in mind a few general rules as to the direction and rate of movement of the Low and High, with the blowing of the wind from the High toward the Low, and studying the map carefully, coming weather changes may frequently be foreseen. The centers of Lows do not, as a rule, move across isotherms, but follow their general direction. Areas of low pressure frequently move to the south of east from the Rocky Mountains to the Mississippi and then change direction to the north of east over the eastern half of the country. Storms in the Gulf of Mexico occasionally move to the west or north of west, but after reaching the coast, they generally change direction and move to the northeastward. High areas move to the southeast and are usually attended by fair and cool or cold weather. A cold wave is always accompanied by a High.

The cloud and rain area in front of a Low is generally about the size of the latter and oval, with the west side touching the center of the Low in advance of which it progresses.

When the isotherms run nearly east and west no decided change in temperature will occur. If the isotherms directly west of a place incline from northwest to southeast, it will be warmer; if from northeast to southwest it will be colder. Southerly to easterly winds prevail west of a nearly north and south line passing through the middle of a High, also east of a like line passing through the middle of a Low. Northerly to westerly winds occur west of a nearly north and south line passing through the middle of a Low and also east of a similar one through the middle of a High.

An absence of decided waves of High or troughs of Low pressure indicates a continuance of existing weather which will last till later maps show a change, usually first appearing in the west.

The temperature of the air as published on the map is observed with a dry-bulb thermometer, and also with a wet-bulb thermometer—that is, one whose bulb is covered with a moist wrapping. The evaporation from the wetter surface, if the air is not saturated with moisture, is more rapid than from the dry bulb, in proportion to the relative amount of aqueous vapor in the air. The difference of temperature between the readings of these two thermometers suffices to compute the relative humidity of the atmosphere. The temperature of the wet bulb is lower than that of the air as given by the dry-bulb thermometer, on account of the evaporation from its bulb. The wet-bulb temperature is sometimes called the sensible temperature, because the sensation of heat on the skin agrees more closely with its indications than with those of the dry thermometer.

A study of these charts, with their succession of highs and lows will make it clear why bad weather in the eastern part of the United States almost invariably begins with an easterly wind and clears with a cold northwester.

It should be noted that highs and lows must of necessity

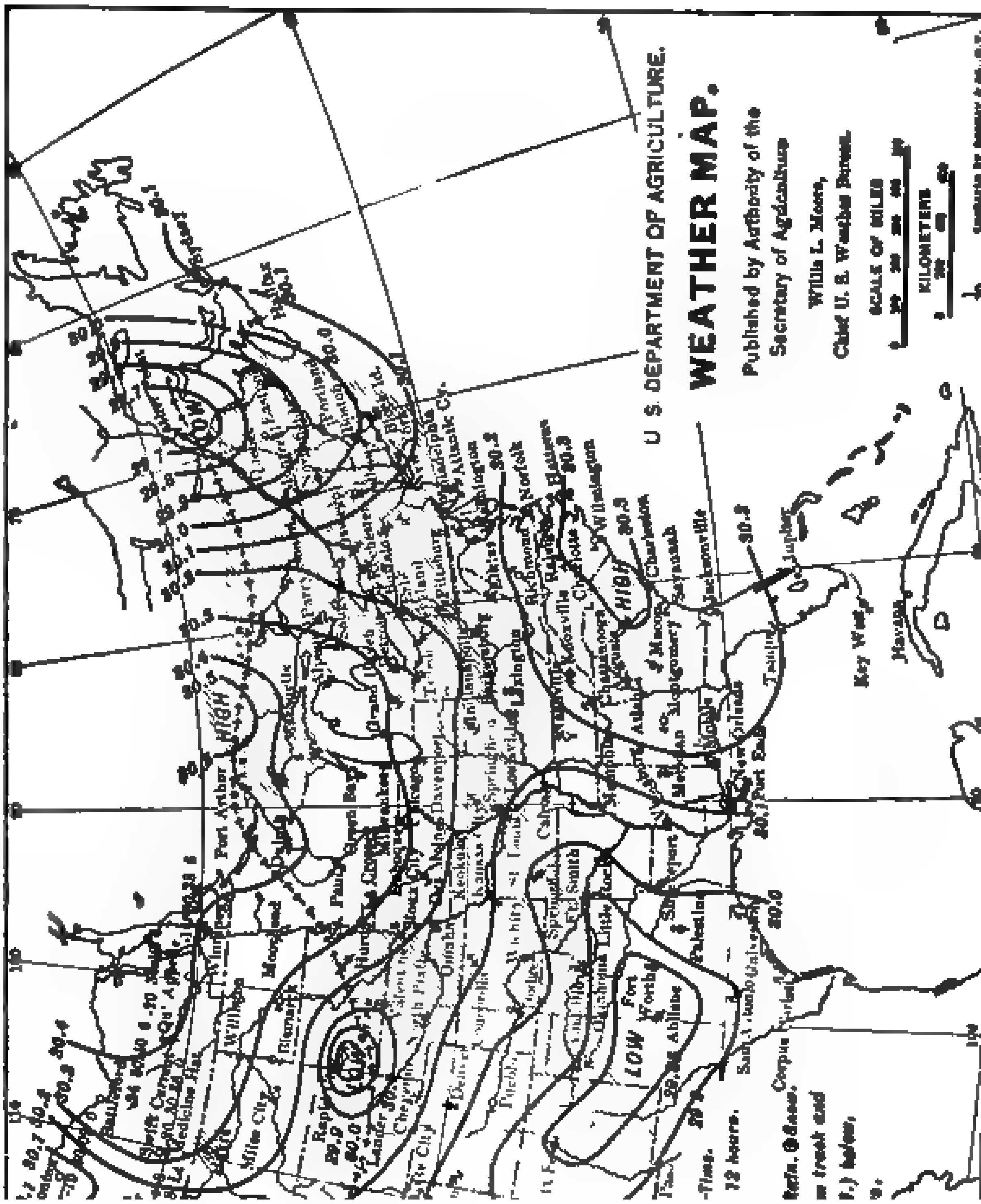
accompany each other, since the inward draft of air in a low implies the existence of a neighboring high, from which the wind flows outward. The relation between the two is shown in Fig. 1, Plate **149.**

After the circulation of the winds, the most interesting and important features in connection with weather changes are the phenomena of precipitation, and temperature changes. It has already been explained why there is a tendency toward precipitation in the upward draft of a low; but it is found that in the case of the lows moving to the eastward across the United States, the precipitation is much greater along the forward part of the storm and in its eastern and southern quadrants than to the northward and westward. The explanation of this is that the winds of the eastern and southern quadrants are largely drawn from the warm regions of the southern states and from the Gulf of Mexico, and are charged with moisture which they deposit as they sweep northward and rise at the same time into the cooler regions of the upper atmosphere. This explains why, in north latitudes, rain comes with an easterly or southerly wind.

The winds of the northern and western quadrants are relatively dry and cold.

The same explanation suffices in a general way to account for the succession of cool and warm waves which are the more or less marked accompaniments of the *highs* and *lows*. It has already been explained that a *low* is, in its essential nature, an area of upward tending warm air, while a *high* is an area of downward-flowing cold air. But an inspection of our weather maps will show that in addition to this we have, on the forward side of an advancing low, a southerly or southeasterly wind, drawing up from the warm regions of the tropics; while the front of a high is made up of northerly winds sweeping down from British America.

Where a low originates in the tropics, it moves at first westward instead of eastward, being carried along by the general movement of the atmosphere. At the same time it works more or less toward the north (or south) and in the end becomes involved in the eastward current above described. Under the influence of this current it recurves and sweeps off to the east-


U S DEPARTMENT OF AGRICULTURE.
WEATHER MAP.
Published by Authority of the Secretary of Agriculture.
Willis L. Moore,
Chief U. S. Weather Bureau.
SCALE OF MILES
KILOMETERS
HIGH
LOW

ward, taking its place in the procession of highs and lows which have already been discussed.

The laws of atmospheric circulation which have been outlined above are subject to many exceptions and modifications, due to the irregular distribution of land and water and to other circumstances which break up the symmetry of an ideal globe. The predominance of land in the northern as compared with the southern hemisphere is the most important factor in modifying the general law.

Of the modifications thus introduced, the most marked and important is the enormous change over the continent of Asia from winter to summer, causing the phenomenon known as the reversal of the monsoons;—a phenomenon which is of vital importance to half the inhabitants of the globe.

This extensive continental area is excessively heated during the summer months and the air in contact with its surface becomes heated and rises, creating an upward draft of sufficient power to overcome the effect of the similar draft in the equatorial belt and to turn back the N.E. trade wind on its track, converting it into a S.W. "monsoon" which blows steadily and often violently, for several months of the year; after which, the continent having cooled down sufficiently to restore the normal balance of pressures, the trade wind again sets in;—under the local name of the N.E. monsoon.

These phenomena are strictly analogous to the alternation of land and sea breezes which characterize the summer climate of nearly all sea coasts. The land becomes abnormally heated during the day, the air above it rises, and a breeze draws in from seaward which continues until toward evening. During the night the land radiates its heat more rapidly than the water, the relative temperature and barometric conditions are reversed, and the land-breeze springs up and blows throughout the night.

Reverting once more to Plate 148, attention may be called to the marked contrast between winter and summer conditions throughout the earth's surface, as regards not only temperatures, but pressures and wind-circulation as well.

It will be noted that the winter storms of the North Atlantic are not usually tropical in their origin, but begin, as a rule,

in the region of westerly winds and sweep across, usually well to the northward, following the general course of these winds. They are, in fact, in many if not most instances, identical with storms which have already swept across the North American continent; and in some cases it is possible to trace their history far back over the Pacific.

If it were possible to add still more data to Plate **148,** it would be of interest to show the average amount of cloud, winter and summer; the precipitation in the form of rain or snow; the regions of maximum and minimum departure from normal temperature and pressure, and the amount of such departure; and the average daily range of the thermometer and barometer, together with the daily barometric tides. Were such data added it would be seen that the cloudy rainy regions are those of the equatorial calm belt and the high latitudes of the temperate zones, where low pressures indicate ascending currents; and that the tolerably clear regions are the belts of high pressure along the 30th parallels, with more cloudiness over the oceans and less over the continents, but entirely clear skies over the great deserts and in the lee of mountain ranges only. The rainfall data would show clearly the influence of prevailing winds in carrying moisture from the oceans to the continents, sometimes far inland over level land, sometimes only as far as a mountain range that chills and precipitates the aqueous vapor. The winds carry the temperatures, too, of the oceans they traverse, and thus modify weather and climate, with a tendency toward warmth rather than cold, inasmuch as the condensation of the vapor which they carry sets free large quantities of latent heat. Where storm tracks are numerous the rainfall is heavy; witness the case of cyclones which carry moisture with them from the Bay of Bengal to the foothills of the Himalayas producing rainfalls of 30 and even 40 inches a day, which may be contrasted with an average daily rainfall of $\frac{1}{10}$ inch in most parts of the United States. The great variations from normal temperature and pressure that occur in the stormy high latitudes of the temperate zones contrast forcibly with the uniformity and regularity within the tropics. The daily range of the thermometer depends on whether it is winter or summer, clear or cloudy; that of the barometer, on the position of the region relative to the tracks and number of passing cyclones

and anti-cyclones. The barometric tides, slight in themselves but moving in the equatorial regions with the regularity of clockwork, with daily forenoon and evening maxima and early morning and evening minima, are often obscured in higher latitudes by the far greater changes due to passing storms, and are modified a little everywhere by the effect of continents close by. All of these phenomena, so closely inter-related, may be studied in connection with the fundamental data represented graphically in Plate **148.**

THE BAROMETER.

It will be evident from what precedes, that the barometer is beyond comparison the most important of the instruments available for forecasting weather, and that it is deserving of much more exact attention than it commonly receives on shipboard. It should be carefully placed where it will hang vertically and be subject to a temperature not widely different from that of the outside air. A thermometer should be attached to it or placed near it, and the temperature indicated by this thermometer entered with every reading of the barometer recorded. Comparison should be made from time to time with a standard barometer in ports where such an instrument can be found. For this comparison it is not necessary to bring the instruments together, but only to get practically simultaneous readings and to apply the proper corrections for temperature. A comparison carefully made, with the proper corrections, gives an instrumental error which may be checked from time to time as opportunity permits, and makes it possible to compare the readings of the instrument with data published on Weather Charts and in Sailing Directions, as well as to furnish additional reliable data for publications of that kind.

It will add to one's interest in keeping a good barometric log to know that others can easily check its accuracy, both at once and years hence. For instance, suppose you make a voyage from New York to Liverpool, thence to Hamburg, Cape Town, Melbourne, and Yokohama. Whenever you pass within a few miles of another vessel, or of any port or coast of a country where daily weather maps are published (such as the United States, England, Germany, France, Cape Colony, Australia, and Japan), a comparison of your log with other good logs, or with the published observations that are available in the libraries of government and other offices all over the world, will give any one that chooses to make it, a perfect check on your record. If it stands the test, it becomes a

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PRINCIPAL FORMS OF CLOUDS (AFTER KÖPPEN).

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PRINCIPAL FORMS OF CLOUDS (AFTER KÖPPEN).

good check on other logs and valuable for study. Very few aneroids will stand this rigid and long-continued test of reliability, however useful they may be in showing changes of pressure from time to time in practical use at sea.

To draw conclusions from the reading of the barometer we must know the normal pressure of the place and time of observation. These are shown for mid-winter and mid-summer in most parts of the world on Plate **148,** and should be given for all places and seasons in Sailing Directions. The importance of this point is indicated by the fact that a corrected pressure of 29.40 is normal for high southern latitudes, but very low for corresponding latitudes north.

The normal pressure at any given place may be expected to show the regular daily fluctuation or "barometric tide," already referred to, and which is entirely independent of variations connected with the weather. This fluctuation is greatest in the tropics and disappears in very high latitudes both north and south. The extreme daily range in the tropics is in the neighborhood of $\frac{1}{10}$ of an inch. The maxima occur about 10 o'clock, the minima about 4 o'clock, A. M., and P. M. Apart from the daily tides, the variations in barometric pressure are slight within the tropics, while in high latitudes they are very marked.

CLOUDS.

The relation of cloud-forms of various kinds to weather, either existing or in prospect, is a matter of the greatest importance; but unfortunately our knowledge upon this subject is still very limited. The usual classification of cloud-forms is shown in Plate **152,** and the following notes give in condensed shape about all that is known with regard to their significance.

DESCRIPTION OF CLOUD-FORMS (PLATE 152).

The following cloud-forms are arranged according to a general descending scale of altitude, observation having shown that there are five main cloud levels; viz.: cirrus (highest), cirro-cumulus, alto-cumulus, cumulus, and stratus (lowest).

1. **Cirrus (Ci.)**.—Detached clouds, delicate and fibrous looking, taking the form of feathers, generally of a white color, sometimes arranged in belts which cross a portion of the sky in great circles, and, by an effect of perspective, converge toward one or two opposite points of the horizon. (The Ci.-S. and the Ci.-Cu. often contribute to the formation of these belts). The height of cirrus is from 5 to 6 miles.

2. **Cirro-Stratus (Ci.-S.).**—A thin, whitish sheet, at times completely covering the sky and only giving it a whitish appearance (it is then sometimes called cirronebula), or at others presenting, more or less distinctly, a formation like a tangled web. This sheet often produces halos around the sun and moon. Average height about 5½ miles.

3. **Cirro-Cumulus (Ci.-Cu.).**—Small globular masses, or white flakes without shadows, or having very slight shadows, arranged in groups and often in lines. Height about 4 miles.

4. **Alto-Cumulus (A.-Cu.).**—Rather large globular masses, white or grayish, partially shaded, arranged in groups or lines, and often so closely packed that their edges appear confused. The detached masses are generally larger and more compact (changing to S.-Cu.) at the center of the group; at the margin they form into finer flakes (changing to Ci.-Cu.). They often spread themselves out in lines in one or two directions.

5. **Alto-Stratus (A.-S.).**—A thick sheet of a gray or bluish color, showing a brilliant patch in the neighborhood of the sun or moon, and which, without causing halos, may give rise to coronæ. This form goes through all the changes like the Cirro-stratus, but, by measurements made at Upsala, its altitude is one-half less. Height about 3 miles.

6. **Strato-Cumulus (S.-Cu.).**—Large globular masses or rolls of dark cloud, frequently covering the whole sky, especially in winter, and occasionally giving it a wavy appearance. The layer of Strato-cumulus is not, as a rule, very thick, and patches of blue sky are often visible through the intervening spaces. All sorts of transitions between this form and the Alto-cumulus are noticeable. It may be distinguished from Nimbus by its globular or rolled appearance, and also because it does not bring rain. Average height about 1 mile.

7. **Nimbus (N.).**—Rain clouds.—A thick layer of dark clouds, without shape and with ragged edges, from which continued rain or snow generally falls. Through the openings of these clouds an upper layer of Cirro-stratus or Alto-stratus may almost invariably be seen. If the layer of Nimbus separates into shreds, or if small loose clouds are visible floating at a low level, underneath a large nimbus, they may be described as Fracto-nimbus (Fr.-N.), " Scud " of sailors.

8. **Cumulus (Cu.).**—Wool-pack clouds.—Thick clouds of which the upper surface is dome-shaped and exhibits protuberances while the base is horizontal. These clouds appear to be formed by a diurnal ascensional movement which is almost always observable. When the cloud is opposite the sun, the surfaces usually presented to the observer have a greater brilliance than the margins of the protuberances. When the light falls aslant, these clouds give deep shadows; when, on the contrary, the clouds are on the same side as the sun, they appear dark, with bright edges.

The true Cumulus has clear superior and inferior limits. It is often broken up by strong winds, and the detached portions undergo continual changes. These may be distinguished by the name of Fracto-cumulus (Fr.-Cu.).

9. **Cumulo-Nimbus (Cu.-N.).**—The Thunder-cloud; Shower-cloud.—Heavy masses of clouds rising in the form of mountains, turrets, or anvils, generally having a sheet or screen of fibrous appearance above

(" false Cirrus "), and underneath, a mass of cloud similar to " Nimbus." From the base there usually fall local showers of rain or of snow (occasionally hail or soft hail). Sometimes the upper edges have the compact form of Cumulus, forming into massive peaks round which the delicate " false Cirrus " floats, and sometimes the edges themselves separate into a fringe of filaments similar to that of the Cirrus cloud. This last form is particularly common in spring showers.

The front of thunderclouds of wide extent frequently presents the form of a large bow spread over a portion of the sky which is uniformly brighter in color.

10. **Stratus (S.).**—A horizontal sheet of lifted Fog.—When this sheet is broken up into irregular shreds by the wind, or by the summits of mountains, it may be distinguished by the name of Fracto-stratus (Fr.-S.).

NOTE.—The attention of mariners is especially called to the value of observations of cirrus, as this form of cloud is often closely connected with barometric depressions. If the cirrus occurs in radiating bands crossing the sky, the point of convergence of these bands should be noted; if in the form of a cloud bank, or sheet, upon the horizon, the center, or point of greatest density of this bank; as this point will sometimes serve to indicate in a general manner the direction of the center of any cyclonic disturbance.

§ II. THE LAW OF STORMS.

The general features of this law have been enunciated in the preceding pages; for the storms with which the law deals (in its special application to Seamanship), are simply cyclones or *lows* like those already described, but with all their characteristic features intensified and concentrated within comparatively narrow limits.

These storms, variously known as "Cyclones," "Typhoons," "Tropical Hurricanes," etc., have their origin over the ocean and on the border-land between the equatorial hot-belt and the trade-wind region, where unsettled conditions would naturally be expected to prevail. Many theories have been put forward to explain their origin, but none which is entirely satisfactory. The generally accepted theory connects the development of the disturbance with the existence, as a preliminary, of excessively sultry, rainy, and squally conditions in the lower layers of the atmosphere, and the coincidence in the upper layers, of temperatures lower than those due to the normal decrease of temperature with the altitude. This is evidently a condition of unstable equilibrium and sooner or later results in the formation of ascending currents and a general overturning of the atmosphere, with a sudden and violent inrush of air from all the

FIG. 1. WIND CIRCULATION IN HURRICANE,
NORTHERN HEMISPHERE.

FIG. 2.
CROSS-SECTION OF HURRICANE, SHOWING
CLOUD-BANK, CENTRAL CALM AND STORM-WAVE.

surrounding regions. This action, once commenced, is increased in intensity by the formation of clouds and rain in the ascending air, resulting in the liberation of heat, which acts to increase still further the violence of the upward- and inward-rushing currents. The air flowing in takes up the characteristic cyclonic rotation which has already been described and explained, and the hurricane vortex is established, with extremely low pressure and a clear calm space of small diameter at the center. In this vortex and the surrounding whirl there are different degrees of rotation to the different layers of the atmosphere, beginning at the base with an inward spiral which diverges by perhaps two points from a circle (at a distance from the center) and ending at the top—many miles above the base—with currents radiating almost directly outward. An attempt is made to indicate this circulation in Plate **153**. The successive layers of air are marked by different cloud-forms resulting from the special conditions to which the moisture in the swirl finds itself subjected. The lowest layer above that at the surface is marked by low fast-flying scud, which is observed to move in what is practically a circle; above this and diverging slightly outward is a layer of cumulus, and above this come in succession alto-stratus, cirro-cumulus, and in the rare, cool atmosphere six miles and more above the surface, the long feathery plumes of cirrus, radiating almost directly outward. Naturally, these successive layers of cloud are not distinguishable by an observer actually involved in the storm, as his view is bounded by the heavy scud over his head; but they can be more or less clearly made out from a distance, the cirrus clouds in particular being distinguishable above the heavy bank beneath, and indicating by the point from which they radiate, the bearing of the center of the storm. Great activity of movement in the upper clouds, observed while the center is still distant, indicates a storm of great severity. If the cirrus plumes are faint, fading gradually behind the slowly thickening veil, the storm is an old one of large area; if they are of snowy whiteness, projected against a clear blue sky, it is young and of small area, but of great intensity. The general direction of translation is at first toward the west, but with a slight tendency away from the equator which becomes more and more marked, until the storm sweeps around altogether, and, in the region of westerly winds, moves off to the eastward. The velocity of translation

Fig. 1
Sept. 6, 8 A. M.

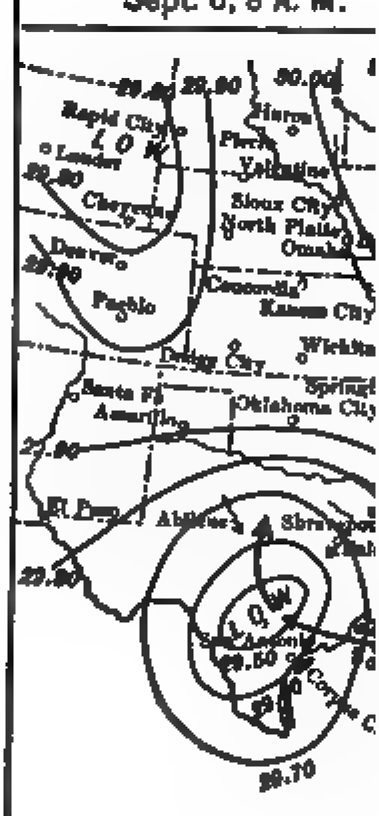
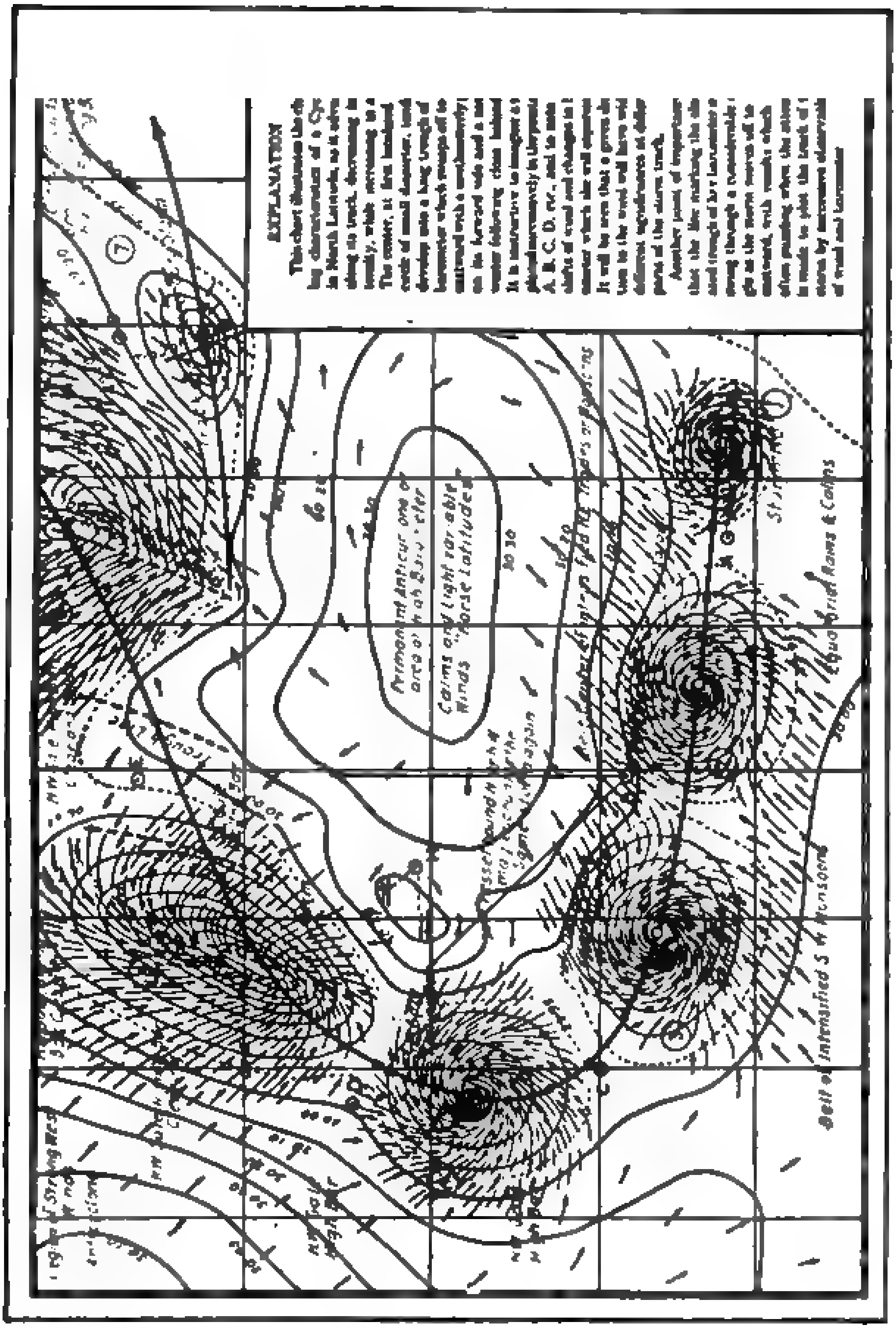


Fig. 2
Sept. 9, 8 A. M.

GALVESTON HURRICANE SEPTEMBER 1900.

varies from a few miles an hour to as much as twenty-five or thirty miles, being greatly affected by the barometric pressures prevailing *in the regions towards which it is advancing.* Thus a storm advancing toward the Atlantic coast of the United States may find prevailing over the continent and the coasts, an area of very high barometer against which it comes up as against an elastic but impenetrable barrier. It may thus be slowed down and held back, or, as frequently occurs, shunted off to one side and entirely changed in direction. A striking example of this kind is shown on Plate **154,** where a cyclone which was apparently marked out for a track along the Atlantic coast found its path blocked by a "High" and was finally driven off onto the west Gulf Coast, where it entirely destroyed the city of Galveston. This effect is similar to that of the fixed area of permanent high barometer shown on Plate **148,** as overhanging the North Atlantic Ocean during the summer months. The storms of this season follow around the outside limits of this area, the existence of which undoubtedly counts for much in determining their course. Their track, in fact, is usually along a trough of low pressure between two highs, one overhanging the ocean, the other the land. Other factors of importance in determining the track of the storms, are the general circulation of the atmosphere, with which they tend to move along, and the existence of such ocean currents as the Gulf Stream in the North Atlantic and the Japanese Current in the North Pacific; the excessive evaporation over these currents tending to create a trough of low pressure such as has been referred to above. The track of such a storm in the North Atlantic is shown in Plate **155,** in which are brought out many points of interest and importance in connection with its progress and development. It will be noted that the shape of the storm, far from being a circle, is a decided ellipse, with a well-marked trough of low pressure along its major axis. In the early stages of its progress the storm is of small area but great intensity. As it progresses, it spreads out and, usually, loses something of its violence; (as is indicated by the increasing distance between the isobars), and in the end sweeps across the North Atlantic as a southeasterly gale with a northwester following close upon it. Taken as a whole, the storm here shown is a summer type, but in the final part of its path it represents also the winter storms of the North Atlantic,



OCEAN CYCLONES AND ANTI-CYCLONES OF THE NORTHERN HEMISPHERE.

A Diagram of Typical Wind Circulation from Anti-cyclones to and around Cyclonic Storm Centers in Oceans North of the Equator, and the Tracks along which Storms Usually Move.

which are none the less cyclonic because they do not originate in the tropics.

Strictly speaking, we should consider this chart to represent, not the progress of a single storm on a number of successive days, but a number of storms existing at the same time. This is not an impossible condition of affairs, although it would of course be an unusual one. For our present purpose, however, we may imagine that the "high" which is shown as hanging over the western part of the area included by the chart has remained stationary for several days (a phenomenon which is not uncommon) and that the storm has made its way through the trough between this high and the permanent anti-cyclone to the eastward.

The chart illustrates the conditions of weather characterizing each portion of the storm, and can be made to show the changes which would be encountered by a vessel passing through the storm along any given line, or lying to and allowing the storm to pass over her. An inspection of this chart will explain most of the characteristic features of bad weather in the North Atlantic; showing why gales commonly begin with the wind at east or southeast and end with it at N.W.; and why the change from one quarter to the other often comes in a sudden shift with violent squalls. This shift is due to the passage of the trough of low pressure into which the originally circular center has been stretched out. (Compare with Plate **150**.)

Among the weather proverbs most firmly believed in by sea-faring men is the one which insists that good weather is not to be expected after a storm in the northern hemisphere if the wind shifts to the left, or *backs*. It will be clear from what precedes, that this is true only for observers in the right-hand semi-circle of the storm. In this semi-circle, as has been shown, the wind shifts to the right as the storm passes, and goes to Northwest by way of South, Southwest and West. In the left-hand semi-circle, on the other hand, the northwest weather of the clear anti-cyclone follows a shift to the left, through Northeast and North.

It happens, however, that the Atlantic and Gulf Coasts of the United States, and the greater part of Europe (including England) lie to the south and east of the average path of the storms to which these regions are subject; and the same is true of the ordinary tracks of vessels in the North Atlantic. Thus it happens that with regard to a very large majority of the storms moving over these regions, observers find themselves in the right-hand semi-circle; and do, as a matter of fact, get their clearing weather by a shift of the wind to the right. This is not true of tropical hurricanes, but it must be remembered that these are few in number in comparison with the storms which originate in higher latitudes. (See Plate 157.)

The velocity of translation of storms varies within wide limits and it is very unsafe to assume even an approximate value for it in any given case. It may be said, however, that the *average* velocity per hour within the tropics is between 15 and 20 knots; that as the storms turn toward the north (or south) they slow down, the average for this part of the path being from 5 to 6 knots; and that as they recurve and start off to the eastward, the velocity usually increases, the average for this part of the track being something like 25 knots. The maximum velocity that has been observed does not much exceed 30 knots. The velocity of rotation varies from 50 to 100 miles an hour and perhaps even more than this. It is evident that on one side of the track, or in one semi-circle of the storm, the velocity of translation will be added to that of rotation, while in the other semi-circle it will be subtracted. This is one of the most important reasons for regarding one semi-circle as "dangerous" and the other as "manageable." Other reasons are that this is the side toward which the storm-track curves, and that on this side the winds and currents tend to set the vessel toward the front of the storm-center.

Rules are sometimes laid down as to the latitude of recurving of storms at different seasons of the year; but such rules are even more dangerous than those which deal with the velocity of translation. The storm tracks plotted on Plate **157** give all the data that are available on this subject, and indicate clearly enough that no rule can be laid down which will not be subject to so many exceptions as to render it altogether valueless.

Plate **153** illustrates on an exaggerated vertical sectional scale the cloud formation, wind circulation and storm wave of a hurricane. The mountainous central mass of cloud, composed of heavy nimbus below and towering leaden cumulus above, often maintains a remarkable fixity of bearing, which, together with its solid rugged appearance, makes it look like distant land. Such a cloud-bank was once visible from Trinidad, Cuba, for five entire days.

The storm wave, or general rise of the level of the sea near the center, due to the inrushing winds and low pressure, moves along with the storm until perhaps precipitated in a great flood upon islands and coasts in its path. Such a flood, the night of

October 31, 1876, in the low lands of the delta of the Ganges, drowned 100,000 people and resulted in the death of as many more through famine and disease. Very strong currents are caused both by the wind force and, apparently, by the advance of the entire storm, which seems to drive the sea bodily before it as well as drag it along behind. Near the coast these effects are most marked, and after a few days in a hurricane, vessels often find themselves 50 or 100 miles out of their reckoning. The widest allowances must therefore be made for current, until the weather clears and good sights can be obtained.

INDICATIONS OF THE APPROACH OF A HURRICANE.

EARLIEST INDICATIONS.—The distant storm usually causes an abnormal *rise* of the barometer, with cool, dry, fresh winds and cessation or reversal of the ordinary land and sea breezes, with a very transparent atmosphere. A long low swell is often noticed at a great distance, sometimes hundreds of miles, with occasional high hurricane rollers. The direction of the swell, when unaffected by intervening islands and neighboring coasts, indicates the bearing of the center; as do also the light feathery plumes of cirrus cloud that radiate from a point of the horizon marked by a whitish arc.

UNMISTAKABLE SIGNS.—As the sky becomes hazy with a thin uniform cirrus veil, halos are noticed by day and night, the barometer begins to fall slowly, the air becomes heavy, hot and moist, with red and violet tints at dawn and sunset; the low but solid and rugged looking cloud-bank of the hurricane appears on the horizon like distant land; squalls break off and diverge from it, and later squalls are noticed passing across the line of bearing of the center of the bank. Fine misty rain forms, seeming to grow out of the atmosphere; a heavy cross sea is felt, and the barometer, while falling rapidly, becomes unsteady.

A vessel situated in front of and near the path of a cyclonic storm will commonly experience a long, heavy swell, a falling barometer with heavy rain, and increasing winds, the direction and changes of which will depend upon her position with reference to the center and the track. A comparison of the three positions of a storm plotted in Plate **156** will show that whereas in Fig. 1, a wind from N.E. or E.N.E. marks a position near

A HURRICANE RECURVING.

Northern Hemisphere.

Southern Hemisphere.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4

Fig. 5.

Fig. 6.

B, in the forward right-hand quadrant (the most dangerous part of the storm), in Fig. 3, the same direction of the wind marks a position near A in the navigable semi-circle and clear of all real danger; while in Fig. 2, it marks a position near C, almost in the track of the storm. This shows the importance of considering the ship's position as to latitude and longitude, in connection with other data; but in attempting to draw conclusions from this it must not be forgotten that the latitude of recurving can be known only in a very general way.

RULES FOR MANŒUVRING.

The rules for manœuvring with reference to a storm have for their objects: 1st, to determine the bearing and distance of the center and the track along which it is moving; 2nd, to avoid the center and, if possible, to keep out of or escape from the dangerous semi-circle; 3d, to ride out the storm in safety if unable to escape from it.

It has been shown that the bearing of the center may in some cases be determined, while the storm is at a distance, by observations of the cloud-bank and especially of the point from which the cirrus plumes are seen to radiate; and in some cases, also, by the direction of the long swell which often precedes the storm. But these indications are confined to the early stages of the storm's advance, within the limits of the tropics. Under other circumstances, the only indications of value are the direction and force of the wind and the action of the barometer. The old rule for determining the bearing of the center was to assume it as eight points from the direction of the wind; to the right in the northern hemisphere and to the left in the southern. It is now known that this eight-point rule is true only near the center of the storm, and that near the edge, the center may bear as much as twelve points from the wind.

The following perhaps expresses as definitely as a rule can express it, this relation between the direction of the wind and the bearing of the center of the storm.

RULE.—*When the approach of a revolving storm is first clearly recognized, the bearing of the center may be assumed as between 10 and 12 points from the direction of the wind. When the characteristic features of the storm are fully developed, the wind having the force of a gale and the barometer falling steadily, the bear-*

ing may be assumed as between eight and ten points. As the storm continues to increase and after the barometer has fallen as much as half an inch, the bearing may be taken as about eight points.

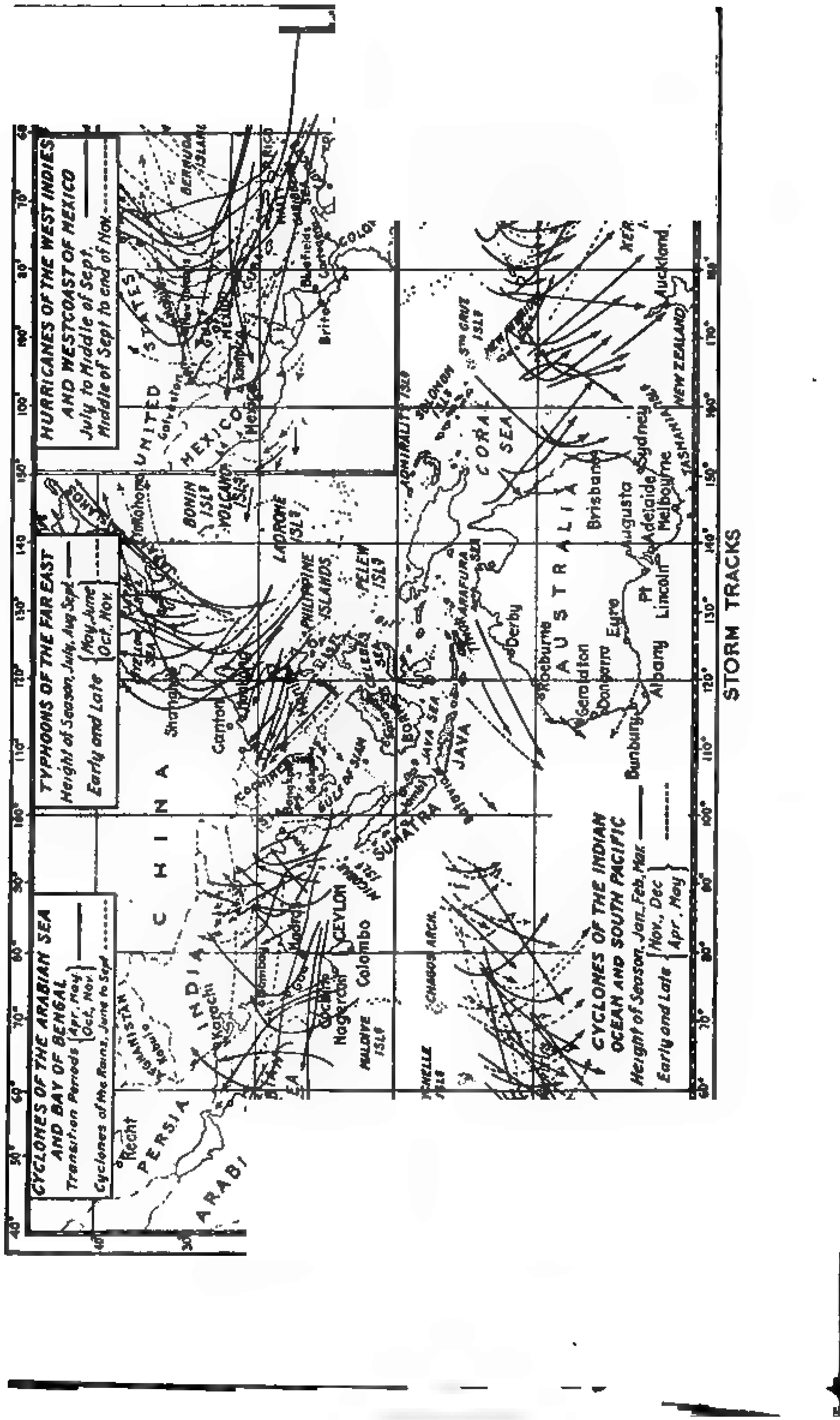
It will be understood that neither this rule nor any other one can take the place of an intelligent comprehension and application of the principles which have been explained in the preceding pages.

For data as to the path of the storm, a vessel must heave-to and note the changes in the bearing of the center, and the fall of the barometer.

Plate **155** shows the changes in conditions which would be noted by vessels over which the storm is passing along the different lines there indicated. The hauling of the wind to the right indicates that the vessel is in the right-hand semi-circle; hauling to the left, that she is in the left-hand semi-circle.

This rule holds for both hemispheres; but whereas in the northern hemisphere the dangerous semi-circle is to the right, in the southern hemisphere it is to the left. In either hemisphere, if the wind continues from the same direction with a steadily falling barometer, the chances are that the ship is in the track of the storm. One important exception should, however, be noted. When a hurricane moves along the edge of a trade-wind or monsoon region, the prevailing winds are intensified over a wide area, without appreciable change in direction, giving rise to what are known as "intensified" trades or monsoons. These are illustrated in Fig. 1, Plate **158.** In this figure, a vessel at A, hove-to, would have a falling barometer, and no change in the direction of the wind. But if she infers that she is directly in front of the center, and runs before the wind, she plunges directly into the vortex. The only safe course under these conditions is to haul off to the right (in the particular case illustrated in the figure), carrying all the sail that is safe and gaining as much ground to that side as is possible before it becomes necessary to lie-to. *It must be remembered that this applies only to the exceptional case of a hurricane encountered on the border of a trade-wind or monsoon belt.*

It is not a matter of indifference on which tack a ship heaves-to while watching the wind, barometer, and clouds, and waiting for the situation to declare itself. Consider, for example, the ships of Fig. 2, Plate **158.** If the ship B, in the right-hand


HURRICANES OF THE WEST INDIES AND WESTCOAST OF MEXICO
July to Middle of Sept.
Middle of Sept to end of Nov.
TYPHOONS OF THE FAR EAST
Height of Season, July, Aug. Sept.
Early and Late May, June Oct., Nov.
CYCLONES OF THE ARABIAN SEA AND BAY OF BENGAL
Transition Periods Apr., May Oct., Nov.
Cyclones of the Rains, June to Sept.
CYCLONES OF THE INDIAN OCEAN AND SOUTH PACIFIC
Height of Season, Jan., Feb., Mar.
Early and Late Nov., Dec. Apr., May
UNITED STATES
MEXICO
CHINA
INDIA
PERSIA
ARABIA
AUSTRALIA
JAVA
SUMATRA
CEYLON
Colombo
Shanghai
Canton
Bangkok
Karachi
Bombay
Madras
Calcutta
Brisbane
Sydney
Melbourne
Adelaide
Augusta
Albany
Geraldton
Roeburne
Derby
Eyre
Bunbury
Pt Lincoln
Auckland
NEW ZEALAND
TASMANIA
CORAL SEA
JAVA SEA
ARAFURA SEA
CELEBES SEA
GULF OF SIAM
PHILIPPINE ISLANDS
LADRONE ISLS
BONIN ISLS
VOLCANO ISLS
PELEW ISLS
SOLOMON ISLS
ADMIRALTY ISLS
MALDIVE ISLS
CHAGOS ARCH.
NICOBAR ISLS
BERMUDA ISLANDS
Galveston
New Orleans
Tampico
Havana
Bluefields
Recht
STORM TRACKS

semi-circle, heaves-to on the starboard tack, the wind and sea will gradually draw aft. If she heaves-to on the port tack, they will draw ahead and she is liable to be taken aback, perhaps in a sudden and violent squall. In the left-hand semi-circle, the conditions are reversed; but here the danger is not in any case as great as in the other semi-circle. The rule is, therefore, in the northern hemisphere, to heave-to *in the beginning* on the starboard tack. If the wind shifts to the right, you are in the dangerous semi-circle and are on the proper tack. If circumstances admit, you may try to work away from the track of the center, close-hauled on the starboard tack. When obliged to lie-to, do so on the same tack.

If, being hove-to on the starboard tack, the wind hauls to the left (ahead), you are in the left-hand or manageable semi-circle, say at A, and heading away from the track of the center. Here you should bring the wind on the starboard quarter and run as long as possible. If obliged to lie-to, do so on the port tack, being careful to make as little headway as possible.

If, the ship being hove-to, the wind remains steady in direction and the barometer continues to fall, it may be assumed, except in the one case which has been discussed above, that the ship is in or near the path of the storm;—say at C. She should run with the wind on the starboard quarter and hold the compass course thus fixed until the barometer begins to rise.

Most of the above rules are reversed for the southern hemisphere. They are summarized for both hemispheres in the following table:

NORTHERN HEMISPHERE.

Heave-to on **Starboard Tack** to note Shift of Wind.

Wind hauls to right	Ship is in right semi-circle DANGEROUS.	Run close hauled on starboard tack. When obliged to lie-to, do so on starboard tack.
" " left	Ship is in left semi-circle Manageable.	Run with wind on starboard quarter. If obliged to lie-to, do so on port tack.
" continues steady	Ship is in path of storm	Run with wind on starboard quarter and keep this compass course. If obliged to lie-to, do so on the tack on which wind and sea will draw aft.

SOUTHERN HEMISPHERE.

Heave-to on **Port Tack** to note Shift of Wind.

Wind hauls to right	Ship is in right semi-circle Manageable.	Run with wind on port quarter. If obliged to lie-to, do so on starboard tack.
" " left	Ship is in left semi-circle DANGEROUS.	Run close hauled on port tack. When obliged to lie-to, do so on port tack.
" continues steady	Ship is in path of storm	Run with wind on port-quarter and keep this compass course. If obliged to lie-to, do so on the tack on which wind and sea will draw aft.

For plotting the position of the ship within the storm from time to time it is convenient to construct a storm-card like Fig. 2, Plate **158.** This should be on tracing cloth and on a good scale. The ship is then drawn on a sheet of paper and the storm-card moved over it in accordance with the motion of the center as determined from the successive observations made as above described. A rough estimate may generally be made of the distance of the center, from the character of the weather, the force of the wind, the fall of the barometer, etc.

It is hardly necessary to say that circumstances may require the modification of the foregoing rules in many directions. One of the most frequent reasons for such modifications is the proximity to land. The influence of this point upon the course to be adopted will be greatly affected by the way in which it is known that the wind will shift. There is less danger in closing with a coast if it is certain that the shifts of wind will be off-shore and not on. So with regard to seeking an anchorage. It may be safe to anchor in an open roadstead if the shifts of wind are bound to be such as to give a lee; it would be hazardous to anchor if the reverse were the case.

Naturally, also, the seaworthiness of the ship, her speed, and many other conditions, are factors in the problem of manœuvring.

The latitude in which the storm is encountered makes a difference because of the difference in intensity; and a vessel may

CYCLONES.

safely hold her course through a storm in the North Atlantic which she would take every means to avoid in the tropics. On the other hand, it is easier to avoid a storm in the tropics than in high latitudes, because of the difference in the area which it covers. The diameter of a hurricane in the tropics rarely exceeds 300 miles, while in high latitudes it may be a thousand miles or more.

The curvature of the track must be taken into consideration. Vessels have been known to escape from a slow-moving hurricane toward the concave side of the track, only to run into it again after it had recurved.

The preceding directions have especial reference to sailing vessels, but in their general principles they are perfectly applicable to steamers. There is, however, this important difference to be noted; that as a steamer is not dependent for her course upon the direction of the wind, she is much freer to manœuvre and may almost always, unless in the neighborhood of land, keep far enough from the center of the storm to avoid all serious danger. This, however, is true only when the storm is of comparatively limited area and with a center clearly defined; as in positions 1, 2, 3 and 4, of Plate **155**. It is evident that when the storm has spread out over thousands of miles, as in positions 5 and 6, with an elongated trough of low pressure in place of a sharply-defined center, it is hopeless for even a steamer to attempt to avoid it. In such a gale, the directions of the following Chapter (Handling a Steamer in Heavy Weather) become important; and if applied with some reference to the changes in weather which may be anticipated from a study of Plate **155**, they furnish all the directions which should be needed to carry a steamer through any gale in which she has a fair amount of sea-room.

Another point of difference between a steamer and a sailing vessel has to do with the rule for lying-to in the manageable semi-circle. The rule for a sailing ship is to lie-to on the "coming-up" tack in spite of the fact that this brings her head toward the center. For a steamer, the rule in general is to lie-to always with the head away from the center, in order that such headway as is made may be all in the direction of safety.

The Pilot Charts of the North Atlantic and North Pacific

Oceans, issued by the Hydrographic Office of the United States Navy Department, should be familiar to all mariners. These are in substance Monthly Weather Maps of the Ocean and contain a large amount of valuable information not elsewhere to be found, upon a great variety of topics.

WEATHER AND STORM SIGNALS.

Most of the maritime nations of the world publish information of weather and winds to be expected and give warnings to mariners by signal and by radio of the approach of storms.

In the United States the system of weather-signals is very complete, information of the approach of storms being received from various stations in the United States and even throughout the West Indies. These warnings are published at the various seaports by the display of flags by day and of lanterns by night, and by bulletins and reports furnished to newspapers. (Plate 159.) Every effort is made to give these warnings as early as possible at all points where they may be of service to mariners and others.

UNITED STATES STORM SIGNALS.—Storm signals are displayed by the United States Weather Bureau at a large number of stations situated on the coasts of the United States. Most of these stations are equipped for signalling by the International Code, and are prepared to transmit by telegraph and radio the messages of passing vessels.

The warnings adopted by the United States Weather Bureau for announcing the approach of wind storms are as follows:

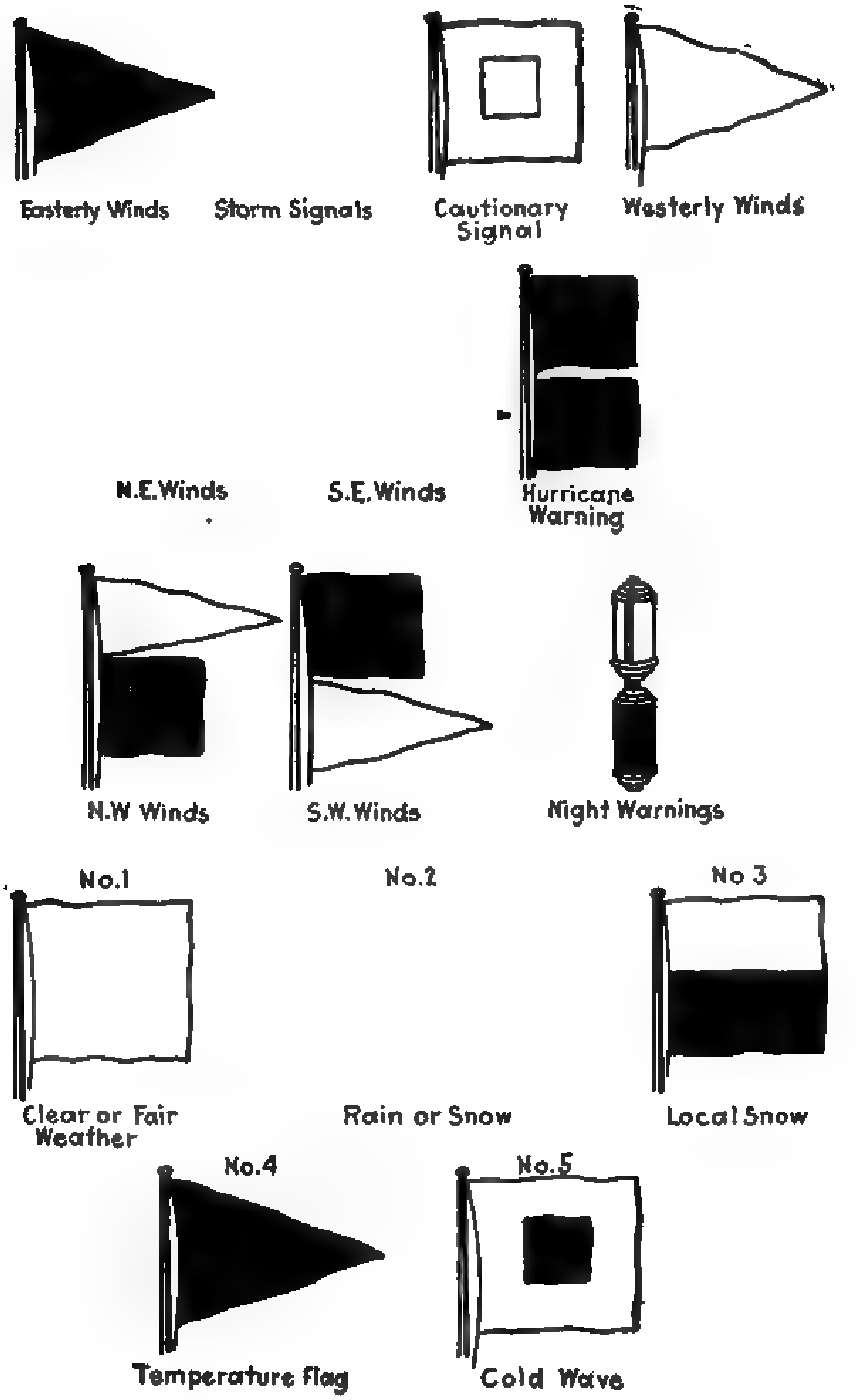
Storm Warning (a red flag, eight feet square, with black center, three feet square), indicates that a storm of marked violence is expected. This flag is never used alone.

Red Pennant (eight feet hoist and fifteen feet fly) displayed with the flags, indicates easterly winds; that is, from the north, through east to south, and that the storm center is approaching.

White Pennant (eight feet hoist and fifteen feet fly) displayed with the flags, indicates westerly winds; that is, from north through west to south and that the center has passed.

Red Pennant if hoisted above the storm warning, indicates that winds are expected from the *northeast quadrant;* when below, from the *southeast quadrant.*

White Pennant if hoisted above the storm warning, indicates



STORM AND WEATHER SIGNALS.

that winds are expected from the *northwest quadrant;* when below, from the *southwest quadrant.*

Night Storm Warnings—By night a *red light* will indicate *easterly winds;* a *white* above a *red light* will indicate *westerly winds.*

Hurricane Warning (two storm warning flags, red with black centers, displayed one above the other) indicates the expected approach of a tropical hurricane or of an extremely severe and dangerous storm.

No night hurricane warnings are displayed.

A yellow flag with white center is a cautionary signal.

Signals should be read from the top of the staff downward. These signals indicate the weather forecasts for the twenty-four hours commencing at 8 o'clock a. m.

UNITED STATES WEATHER SIGNALS.—When displayed on poles, the signals should be arranged to read downward; when displayed from horizontal supports, a small streamer should be attached to indicate the point from which the signals are to be read.

The morning forecasts only (*i.e.,* those issued from the a.m. reports) will be utilized for the display of weather signals, and the flags displayed will represent only the forecast applicable to the twenty-four hours beginning at 8 p.m. of the day the flags are hoisted. (Plate **159.**)

If more than one kind of weather is predicted for the period from 8 p.m. to 8 p.m., the conditions first named in the forecast will be represented by the uppermost weather flag in a vertical hoist, or by the weather flag nearest to the small streamer indicating the point, in a horizontal hoist, from which the signals are to be read. If two temperature forecasts are made for this period, the first-named only will be represented by the temperature flag in its proper position.

When cold-wave signals are ordered, or when the regular forecast contains warnings of a cold wave, the cold-wave signal will be displayed alone, and in no case will flags representing the weather element be displayed on the same staff with the cold-wave signal.

If the forecasts contain a prediction, "moderate cold wave," "decidedly low temperature," "decided fall in temperature," "much colder," etc., the cold-wave flag will not be displayed but the temperature flag will be hoisted below the proper weather flag.

Flags will be invariably lowered at sunset of the day the hoist is made, and no flags will be displayed on the following day until the receipt of the next succeeding morning forecast.

Number 1 indicates clear or fair weather. Number 2 indicates rain or snow. Number 3 indicates that local rains or showers will occur, and that the rainfall will not be general. Number 4 always refers to temperature; when placed above numbers 1, 2 and 3 it indicates warmer weather; when placed below numbers 1, 2 and 3 it indicates colder weather; when not displayed, the indications are that the temperature will remain stationary, or that the change in temperature will not vary more than four degrees from the temperature of the same hour of the preceding day from March to October, inclusive, and not more than six degrees for the remaining months of the year. Number 5 indicates the approach of a *sudden* and *decided* fall in temperature. When number 5 is displayed, number 4 is always omitted.

Examples:—Nos. 1 and 4, "Fair weather. Colder."
Nos. 4 and 2, "Warmer. Rain or snow."
Nos. 4, 1 and 2, "Warmer, fair weather, followed by rain or snow."
Nos. 1 and 5, "Fair weather. Cold wave."

CHAPTER XX.

HANDLING STEAMERS IN HEAVY WEATHER.

§ 1.

The conventional way of handling a steamer when the weather is too heavy for her to proceed on her course is to bring her up until she has the sea on the bow and to hold her there by the engines and the helm, assisted by such after sail as may be available. In this position, most steamers have a constant tendency to fall off, and can only be held up by giving them way enough for the rudder to exercise considerable steering power. They are thus, to some extent, forced into the sea, and the more it is necessary to force them, the greater the strain to which they are subjected, and the greater the probability of their taking water on board in dangerous quantities. This method of riding out a gale has been handed down from the days of bluff-bowed sailing ships and of steamers with more or less complete sail power. Such ships were held up to wind and sea by their ample after sail, with little or no headway. If they fell off—as from time to time they did—and started to gather way, the hard down helm and after sail would bring them promptly back to meet the sea. Thus they came up and fell off, making some little way through the water, but none of it against the sea; and, in the main, drifting steadily to leeward. For such ships, this was and is the ideal way of riding out a gale. But a modern steamer, whether man-of-war, liner or tramp, carries very little after sail and is commonly long and sharp. The propeller acts as a drag, tending to hold her stern up to the sea, and this tendency is assisted by the excess of draft which such steamers usually have aft. To hold such a steamer bows on to the sea, she must be forced into it—not at great speed, perhaps, but sufficiently to strain the ship severely and to suggest grave doubt as to the wisdom of this method of lying to.

The opinion is gaining ground of late years that a steamer of this type should run slowly before a sea or lie to with the

sea astern or on the quarter; and this view is supported both by theoretical considerations and by a convincing amount of practical experience.

If we watch any buoyant object floating in waves which are of some size as compared with the object itself, we shall see that so long as it floats freely, it floats easily, with no indication of strain and with little or no wash on its upper surfaces. If it is forced to lie in some other position than that which it naturally takes, all this is changed; it ceases to ride easily, and the waves break over it more or less. If it is forced through the water, even on the heading which it naturally takes, signs of strain become apparent, and the sea washes over it. If it is forced *against* the sea, the wash will be greater than on any other course, and as the speed in this direction increases, it dives into and cuts through the waves instead of riding over them.

We might anticipate for this that the easiest position for a ship in a heavy sea would be that which she would herself take if left at rest and free from the constraint of engines, helm and sails. For steamers of the type we are now considering (modern steamers of average characteristics), this seems to be generally true. Such a steamer, if left to herself in a seaway will usually fall off until she has the sea abaft the beam, the propeller acting as a drag and holding her stern up. In this position she will roll deeply, but easily, and will drift to leeward, leaving a comparatively smooth wake on the weather beam and quarter, rolling deeply, but in most cases easily, and taking little or no water on board. If oil is used along the weather side and astern, the wake can be converted into an "oil-slick" and all danger of seas breaking on board effectually prevented.

If she rolls dangerously, she may be kept away more, either by setting head sail, by using a drag over the stern, or by turning over the engines just fast enough to give her steerage-way; for it seems to be established also, as the result of experience, that a steamer may safely run with the sea aft or quartering, *provided she runs very slowly*. Clearly this is not "running" in the old sense of that term, according to which a vessel going before the sea was forced to her utmost speed with the idea of keeping ahead of the waves, which were expected to "poop" her if they overtook her. It will be seen from the statements of a large number of shipmasters who have tried the experiment of slowing down or stopping when running before a heavy sea, that

this manœuvre, so far from resulting in the disaster which many seamen would expect from it, had an extraordinary effect in easing the ship and keeping her dry.[1]

The explanation of this seems to be that a ship running at high speed through the water draws a wave after her which follows under her counter and rolls along toward the waist on either side, tending continually to curl over and break on board. This wave is reduced to insignificant proportions in running dead slow.

Another point which enters into the behavior of a vessel going before the sea is that as she rolls and pitches she buries first one bow and then the other, increasing the pressure on the bow so buried. If, now, she is being driven through the water, her head will be forced off, first to one side and then to the other, causing her to yaw badly with a continual tendency to broach to; and this cannot be met by the rudder, because, at the very time the bow is buried, the stern is lifted more or less out of the water, and the rudder loses, for the moment, its steering power. As the stern is lifted, there also comes a racing of the propeller which is in itself a serious danger at high speed. Whether these points be sufficient to entirely explain the fact or not, there seems no question that the dangers connected with running, so far from being increased, are greatly reduced if not altogether removed, by slowing or stopping.

It will of course be understood that in this matter, as in all others connected with Seamanship, due regard must be had for the peculiarities of the individual ship; and that the manœuvre which is safest for a majority of ships may be dangerous for certain ones. Thus a ship whose cargo is of a kind that may shift should not be allowed to roll excessively;—nor should a battleship whose heavy guns are carried high above the center of gravity. The same is true to some extent of sailing ships, whose spars may be endangered by rolling too deeply. For such vessels, a course and speed should be maintained which will keep them reasonably steady, even though this may involve some strain upon the hull and some risk of shipping water. But on whatever course the vessel may be kept, this rule may be regarded as of universal application;—that, other things

[1] See § III of this Chapter for the testimony of shipmasters on this subject.

being equal, *the lower the speed at which she is run, the easier she will be.*

Attention may be called here to an important relation, not always recognized, between a ship and the waves in which she floats. For every ship (in a given condition as to trim, &c.), there is a perfectly definite " rolling period "; a period, that is to say, in which she will make a complete roll, *without regard to whether she is rolling ten degrees or forty.* So, also, in the case of a seaway, there is usually a fairly regular interval of time between wave-crests passing a given point. If the point is a ship in motion, her motion may increase or decrease the interval between the waves so far as she herself is concerned; but this will not change the *regularity* of the interval. If, now, it happens that this interval coincides with that required for the ship to complete a roll, each wave as it passes her will add its rolling impulse to the accumulated effect of those which have preceded it, and the ship will roll more and more deeply until she reaches *the maximum roll of which she is capable.* She will not roll over, if properly designed, because there are forces at work to resist the rolling, and these increase as the depth of roll increases, until the rolling forces and the resisting forces balance. But she will continue to roll to the maximum limit until something is done to break up the synchronism between her period and that of the sea. This can be accomplished, *provided the ship has headway,* by changing the course or the speed or both; thus changing, not the real, but the apparent, period of the waves. By running more nearly into the sea—meeting the waves—the apparent period is shortened; by running more nearly before it, the period is lengthened; but in either case it is *changed* and will no longer agree with the rolling period of the ship. The same effect is produced by a change of speed. If, therefore, it is judged from the violence of the rolling on a given course that the period of the waves is coinciding with that of the ship, the course or speed or both should be changed to break up the synchronism.

The length of the ship, as compared with that of the waves, is also a very important factor in the behavior of the ship, especially when she is running more or less with the waves, or meeting them. It often happens that a small, short ship, in a long sea, will be perfectly comfortable where a larger and longer one makes very bad weather. The small craft climbs up and slides down

the waves, accommodating herself to their slopes, and pitching only as the slope changes; while the longer craft, partially spanning the crests and the hollows of the waves alternately, one end being poised on the crest of one wave while the other end is buried in the adjoining one, may be making very heavy weather. A few years ago a large cruiser in the Philippines was very badly battered by a typhoon, while a small gunboat which passed through the same gale at very nearly the same place, was perfectly comfortable. A Cuban revenue cutter, less than 100 feet long, was caught in one of the heaviest cyclones of recent years some twenty miles south of Cienfuegos and rode it out not only without discomfort but without damage to a light dinghy which she carried rigged out at davits overhanging the side and only eight feet above the water. There are many other similar cases on record. It is no unusual thing to hear that a vessel has foundered in a gale, and that her boats have ridden out the same gale in safety. The great difficulty here is to load the boats and get them clear of the ship. Once clear, they are often much safer than the ship.

If, when a steamer is before the sea or in the trough, it is decided to bring her up to it, bows-on, she should first be slowed until she has barely steerage way, and should then be brought up as gradually as possible. To put the wheel over with considerable speed on and bring her up with a rush—slapping the sea in the face, as it were—would result in serious damage, if not in foundering. After getting her up to it, bows-on, the greatest watchfulness is required, first, to avoid falling off into the trough of the sea, as she will try to do the moment she loses way, and second, to avoid driving into the heavy, breaking seas, which will threaten her now and again. There is reason to believe that many of the phenomenal "tidal waves" reported as having suddenly overwhelmed steamers in mid-ocean have been simply the exceptionally heavy waves which build up from time to time in any long continued gale; and that their destructive power was due to the fact that the vessels were driven into them instead of being allowed to drift before them and ride over them unresistingly. An officer should always be kept at the engine-room telegraphs, in lying to bows-on, and an engineer standing by below, to obey his signals instantly. So long as she heads up to it, the more slowly she turns over. the

better. If a heavy sea is seen bearing down upon her, she should be stopped altogether. If she falls off, it will be necessary to increase the speed a little to bring her up, but she must be slowed again as soon as possible.

The use of a *sea-anchor* is advocated by many writers on Seamanship, and it is commonly assumed that by its use any vessel may be held head to sea and enabled to ride out a gale. No doubt this can be done if the anchor is large enough and strong enough. But considering the importance that is universally attached to this method of riding out a gale, it is surprising how little it seems to have been used and how small is the amount of practical evidence available with regard to it. If used with a modern steamer to keep her head to sea, it acts against the drag of the screw, which, as has been seen, tends to keep her *stern-on* to it; and to overcome this it must be very large and very strongly built; otherwise, its effect will be to keep her in the trough of the sea.

With small ships, and especially with sailing ships, it has been tried often and with good results. Such a ship, riding to leeward of a sea-anchor of fair size with an oil bag hauled out to a block on the hawser well clear of the stem, and drifting slowly astern, will ride out almost any gale with safety and comfort. Indeed, as has been said above, this is the ideal position, in very bad weather, *for any vessel which can be made to take and keep it.* But it is doubtful if a large steamer could be made to do this without the use of an anchor too unwieldy to be handled conveniently in a heavy gale. There are certainly few instances recorded of its use with large steamers; and the shipmasters who advocate it for all cases do not claim to have tested it under these conditions.

If, however, the steamer is to be kept *before the sea,* and especially if she is stopped, a sea-anchor may be laid out to windward (and astern) with great advantage, since it will in this case act *with* the drag of the screw instead of *against* it, helping to keep her more nearly before the sea.

A convenient type of sea-anchor is shown in Plate **160.** It is merely a large drag, floating but well immersed, and resisting motion through the water by reason of the large area which it presents. It is attached to a line from the ship by a span and has a tripping-line from its apex, for capsizing it, to admit of hauling in.

In cases where a light drag is needed and no sea-anchor is available, a boat may be used, with a hawser made fast to a span from the bow and stern ring bolts, and to a belly band amidships. Or a long spar (or a number of spars lashed together) may be used, also slung by a span. If a topsail or a heavy awning can be added to such an improvised anchor, it will help to break the seas.

There are cases recorded of vessels having been kept head to sea by paying out their chain cables, unbent from the anchors. Where the water is shallow enough for the chains to drag on the bottom, they are especially helpful; in deep water, they have the disadvantage of burying the bow. A good sized manila hawser, paid out *on the bight* both ends being kept on board, makes a very convenient drag—perhaps the most convenient that could be devised. With both ends leading in through the stern chocks, it would be extremely helpful for holding her stern-on, and with one end at the stern and the other at some point near the beam, she could be held with the sea on the quarter. A block on the hawser would admit of reeving a line for hauling oil bags out and in.

Where the depth of water admits, a stream anchor or a good sized kedge may be let go with a long scope of cable, either chain or rope, and allowed to drag on the bottom. In comparatively shoal water, a vessel may ride out almost any gale, *at anchor,* provided she has a sufficient scope of cable. During the Civil War in the United States, scores of vessels lay at anchor off the Atlantic coast, and rode out gale after gale, winter and summer, without a single disaster. Under such circumstances, the longer the scope the better; and *one anchor with two cables on end* is preferable to two anchors, each with half the scope of chain. The engines may be used, but very cautiously, to relieve the strain on the cable if this should be thought too great.

Some years ago a steamer was caught in a very heavy on-shore gale off the coast of South Carolina with her engines disabled. Being in shallow water, she let go both anchors and at once swung head to wind and sea, tailing on to the shore. The anchors dragged slowly but held her head up to the gale and she drifted stern-on to the beach where she lay for twelve hours or more with tremendous seas breaking over her bow, but with her crew and passengers safe at the stern. She ultimately swung around broad-

side-on, and broke up, but this not until long after all hands had been taken off.

In twin-screw ships, the propellers have not as much drag as with single-screws, and such ships can sometimes be held up to the sea without being driven into it dangerously, by turning over the lee screw very slowly. This is often the best way to lay a twin-screw ship to, although there is nothing in the nature of the case to prevent such a ship from riding easily with the sea astern or quartering.

We may sum up what precedes on the various methods of handling a ship in heavy weather, with the statement that the ship will usually be safest and most comfortable when end-on, or nearly end-on, to the sea, and *drifting before it.*

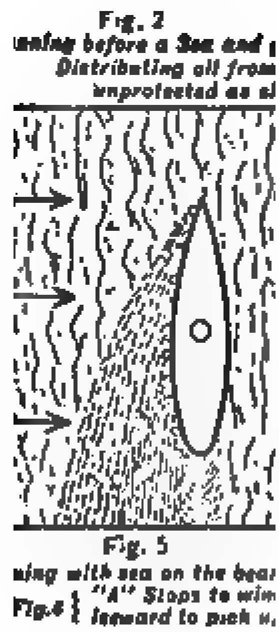
If, by the use of sails, a drag, or any other means, she can be held bows-on, *while being still allowed to drift*, this is probably the best way to lay her to; but if she cannot be held up without being forced into the sea, it will be because of the natural drag of the stern and propeller, and in this case advantage should be taken of this drag to hold her more or less directly *stern-on*, letting her drift in this way.

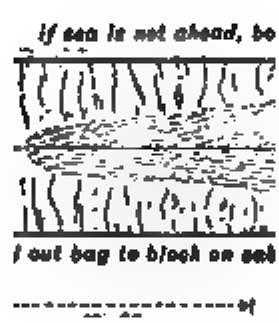
Even if the position she takes up in drifting is nearly in the trough of the sea, it will usually be found that she is easier in this position than in any other, but the use of oil, as described below, is especially important in such cases.

If the position which she takes in drifting proves to be one in which she rolls dangerously, then she may run just fast enough to steer, *but no faster*, and so keep the course which is found most comfortable.

§ II. THE USE OF OIL.

The effect of oil in calming a rough sea has been known from the earliest times, but only very recently has advantage been taken of it to any important extent. The very general use that has been made of it in the last few years is due largely to the researches and publications of the Hydrographic Office of the United States Navy Department. Since that Office took the matter up, a great number of shipmasters have experimented with it, and a mass of evidence has been accumulated which leaves no possible doubt with regard to its utility.





THE USE OF OIL.

The action of the oil is not only to prevent the breaking of waves, but to a considerable extent also to prevent them from forming, and its effect when used on an angry sea is described by all who have tried it as magical. Even in a surf, while it cannot altogether prevent the waves from breaking as they are driven in upon the shoals, it greatly reduces their violence, and will often enable a boat to land when otherwise it would be out of the question.

Almost any kind of oil will give good results, but some kinds are very much better than others. Animal and vegetable oils are best; for example, sperm, porpoise, linseed, olive and cotton seed; and fairly thick and heavy oils are better than lighter ones. Oil of turpentine is probably the best of all. Mineral oils are much less effective, but a very thick sticky oil or one that tends to thicken or congeal in cold weather, may be improved by thinning with petroleum. Soap-suds has a remarkable effect in preventing the formation of waves, but it does not keep them from breaking when formed.

Any method will answer for using the oil which produces a slow and steady flow. A convenient way is to fill the closet bowls with oakum and oil, or to place a can with a tap slightly opened where it will give a slow drip into the bowls and out through the waste-pipes. A still simpler way and one frequently used is to fill a canvas bag, from one to two feet square, with oakum and oil, and punch a number of holes through the canvas with a sail needle. Such a bag may be hung over the side at any point where it is found to give the best result. If there is danger of its being thrown back on board by the sea, its lanyard may be led through an eye-bolt or a shackle in the side. If for any reason a very rapid flow is wanted, a hose may be led through a scupper or over the rail, and the oil poured into it through a funnel—or, in a sudden emergency, the oil may be *thrown* over the side. The quantity used need not exceed a few gallons—four or five at most—even for a large ship riding out a prolonged gale.

The diagrams of Plate 160 show how the oil may be distributed to advantage under various circumstances.[1] To the cases there illustrated, we may add the following:

[1] Adapted from an Essay by Captain Karlowa, of the North German Lloyd S. S. Line.

CROSSING A BAR IN HEAVY WEATHER.

Here the oil is needed for a short time only, but in considerable quantities and on both sides. A convenient way of using it is to trail a hose over the bow or through the hawse pipe on each side and to pour the oil freely through this by means of a funnel.

LOWERING AND HOISTING A BOAT IN HEAVY WEATHER.

A boat is always lowered and hoisted to leeward, with the vessel usually either bow or quarter to the sea. A small quantity of oil slowly poured over the side a short distance forward or abaft the boat (depending upon the way she gets the sea) adds greatly to the ease and safety of handling her and gives her a " slick " in which to come alongside or get clear.

It should be noted that the rate at which the oil spreads is slow in comparison with the speed even of a vessel drifting. Thus a vessel lying with engines stopped can make a " slick " to windward but not to leeward—except, perhaps, very close alongside—because she drifts faster than the oil can spread. So, in running, a vessel can leave a slick astern and to some extent on either hand, but can do nothing to calm the waves ahead of her. She can, therefore, avail herself of the benefits of oil if she is running more or less before the sea, but not at all if steaming into it.

§ III. SOME OPINIONS OF SHIPMASTERS UPON LYING-TO IN MODERN STEAMERS.

The author of the present work has collected the views of forty prominent shipmasters upon the subjects of the preceding pages. Of these, thirty-two strongly advocate either stopping the engines entirely, or turning over dead slow and bringing the sea aft or nearly so. Seven prefer to lie to bows on, but think the other method perfectly safe for most steamers. Three have tried the experiment of stopping the engines, but found the rolling so alarming that they were obliged to bring the sea on the bow. It is an interesting fact that these three were captains of large Atlantic liners.

The following are extracts from a few of the letters received:

Captain Otto Nielsen, S. S. Pennland, writes:

"I have laid-to with engines stopped in a terrible sea whilst in command of the S. S. Switzerland, westward bound, facing for several days a heavy westerly gale and enormous high sea. A heavy sea broke on board carrying away after hatches and companions. As the seas had been breaking over more or less and would continue to do so, filling the 'tween-decks with water, and as it was impossible for anybody to be about decks to repair the damage, I was compelled to stop both engines immediately, at the same time starting both oil tanks going fore and aft on the weather side. In less than a minute I could see the oil spreading up to windward and in less than five minutes it had spread at least 300 feet. The ship kept gradually falling off until she was in the trough of the sea. The heavy seas with breakers would come up to the oil and go under it as if it were a blanket and when they reached the ship it was like a long lazy rolling swell, giving the ship a push, but never a bucket of water coming on board.

Of course the ship rolled considerably but in an easy way, and in fifteen minutes after the engines were stopped the decks were perfectly dry fore and aft."

Captain D. Richardson, S. S. Noranmore, writes:

"I find in the North Atlantic great advantage in lying-to with the quarter to the sea. Put the helm hard up and keep the propeller just revolving to break the sea and prevent the rudder being damaged. Use oil from forward, amidships, and on the quarter. This plan was carried out in the S. S. Baltimore in a hurricane on the 2nd and 3rd of February, 1899, off the Grand Banks when so many steamers were disabled and lost. I escaped with little injury."

Captain H. Doxrud, S. S. Rhynland, writes:

"I prefer to stop engines entirely providing I can run oil out liberally. On the 7th of May, 1898, whilst in command of the American S. S. Pennsylvania, I ran into a hurricane with a tremendous sea. It was impossible without great danger to get along the upper deck, as the seas swept all over her. I was then lying-to, head to sea, and making very bad weather of it. During the height of the storm the engines had to be stopped, the ship fell off with the sea a little abaft the beam and remained so. Oil was used liberally on both sides all the time. The difference in the ship's behavior was simply marvellous. She took little or no water over but was rolling very heavily."

Captain S. W. Watkins, S. S. Montana, writes:

"With my present command I prefer lying-to with the sea right aft, speed reduced and running oil from waste-pipes of W. C.'s, as I find she is much easier that way."

Captain A. R. Mills, S. S. Westernland, writes:

"I prefer to lie to with the engines stopped and the sea quartering. I have tried this several times with different steamers and it worked

streak to windward they shipped no water."

The following extracts are taken by permission from a valuable paper, "Notes on Handling Ships," by Captain D. Wilson-Barker, published by the Shipmaster's Society, London:

Captain A. H. Brown, S. S. Hunstanton, writes:

"In December, 1886, being in ballast, I was running before a westerly gale and high sea for Memel. Knowing that port could not be entered, and that my vessel could not steam against such weather, I decided on rounding to when about 50 miles off shore. The helm was put down, but the steamer would not answer it; she came to the wind about every half hour, immediately fell off again into the trough of the sea, and drove to leeward at an alarming rate. After about two hours I determined to try her stern on, and did so with most satisfactory results, for although the engines were going slow *astern* we held our own, rolling ceased, and she lay *steadily* quarter to sea After a while she paid off to nearly right before the wind, and nothing could be better than her behavior; the helm was kept amidships all the time. So satisfactory was the manœuvre that under similar circumstances I have always adopted it since."

Captain J. G. Groombridge, writing of a spar-deck steamer, 3123 tons gross, 400 H. P., says:

"Off Cape Horn, Bar. dropped 29.60 to 28.80 in. during four hours, the wind increasing to a hurricane, it and the sea abeam, the vessel rolling very heavily and shipping much water, fore and aft. I decided to put her before the wind and stop the engines. She then lay with wind and sea on the quarter, and never shipped a drop of water. After this and two other experiences of like character, let wind and sea be ever so violent, I shall never hesitate to act in a similar way."

Captain Jackson of the S. S. Palamed, writes:

"I have had one experience in a typhoon. I found the ship making very bad weather whilst steaming slowly ahead, so after consideration, I stopped the engines and let her take any position she chose. She gradually fell off until we had the wind about four points on the quarter, and there we lay until the blow was done. We did not take any seas on board from the weather side, the cross swell rolled aboard over the lee side, but there was not the least damage done."

Captain Slessar, of the S. S. Pecheli, writes:

"I was caught between Shanghai and Nagasaki in a very heavy gale and high running sea, the ship at the time in ballast trim. As she was continually falling off I at length decided to let her remain so. She laid with the wind a little on the starboard quarter, the helm amidships, if I remember aright, then the engines *were worked slow astern*, with no appreciable difference as regards ship's position. In this way she lay for 30 hours, riding easily."

The following extracts are taken by permission from letters by shipmasters of high professional standing, published by the Nautical Magazine,[1] as part of a discussion of this subject:

One shipmaster writes:

"The question of riding out a gale with engines stopped is a big one and the answer depends upon the type of vessel and her trim; but this I will say, that on no occasion, when in consequence of break-down of machinery or stoppage of engines from other causes, the vessel in which I have been serving has been allowed to take up her own position, has she shipped any heavy water. Many years ago, in mid-winter, when one of the large Atlantic Liners in which I was serving broke down when homeward bound, during an exceptionally heavy gale, and drifted for more than a week, rolling out gale after gale, the only occasion on which she shipped any heavy water was when an attempt was made to bring her head towards the wind by means of a sail, for in those days the Atlantic Liners had masts and yards and could spread a good deal of canvas. Then she relieved the deck of two boats and a house.

Another shipmaster writes:

"Some few years ago, I was running right before a very high N. W. sea, off Belle Isle, in command of a deeply laden tramp. I never remember either before or since seeing so high a sea running in the Bay of Biscay. When abreast of Belle Isle light, distance seven miles, she pooped a tremendous sea, which washed all our deck gear adrift, and started the after bulkheads of both deck bunkers. I at once came to the conclusion something must be done, and that very quickly, or the ship would founder. I then ordered all hands to lower bridge, all deck openings being battened down, intending to bring her head to sea; I therefore eased the engines to slow, to take the way off her prior to bringing her head to sea. Directly the vessel began to lose her way, the effect was simply magical; she shipped no heavy water at all; so I kept on going easy all night, the vessel making splendid weather of it till dawn, when the storm moderated."

Still another writes:

"On Sunday, Nov. 24th, 9 P. M., very heavy gale and very high sea. Ship scudding dead before the sea. The ship, although a very fine seaboat, kept continually filling her fore well (74 feet in length), chock full from rail to rail.

Before putting my oil bags over, I thought, 'here is a grand chance to try how she acts dead slow.' So I eased the engines to dead slow. The moment she lost her strong headway, the effect was magical. The fore well became nearly dry, only a lipper went over occasionally as it rolled along her side, and the ship was as truly comfortable as she could be wished for."

[1] See an interesting discussion on this subject in the Nautical Magazine for 1895 and 1896.

CHAPTER XXI.

THE HANDLING OF DESTROYERS.

1. **Design.** As preliminary to a discussion of the handling of Destroyers, attention should be called to certain features of the design of such vessels which influence their behavior and which, in many cases, call for altogether different handling from that which would be appropriate for other vessels under similar conditions

The development of the Destroyer has passed through several well-marked stages of design, from the *Decatur* class, of 420 tons, designed in 1898, to the Modern Flush Deck class, of 1,200 tons, with a horse-power identical with that of the superdreadnought *Colorado*. The last-mentioned type is that to which a large proportion of the destroyers belong which for ten years to come (1920–1930) will be in active commission; but there are still a few belonging to the types designed between 1911 and 1916, which, if not in active commission, will continue for some years in reserve and thereafter in the coast defense flotilla. The characteristics of all of these types are shown in the following table.

Year. Authorized.	Number.	Type ship.	L'ngth (feet).	Displacement (tons) Normal.	Horse-power.	Speed (knots).	Armament	
							Guns.	Tubes.
1911..	8	Cassin	305	1,020	16,000	30.00	4, 4-inch	4, 18-inch twin
1912..	6	Cushing	305	1,050	16,000	30.00	4, 4 "	4, 21 " "
1913..	6	Tucker	315	1,100	17,000	30.00	4, 4 "	4, 21 " "
1914 .	6	Davis	315	1,100	17,000	30.00	4, 4 "	4, 21 " triple
1915..	6	Manley	315	1,125	20,000	32.00	4, 4 "	4, 21 " "
1916 } 1917 }	111	Wickes	315	1,170	26,000	35.00	4, 4 "	4, 21 " "
1917 } 1918 }	174	Hatfield	315	1,215	29,000	35.00	4, 4 "	4, 21 " "

GENERAL CHARACTERISTICS, COMMON TO ALL CLASSES.

Beam, 31 ft. (approximate).
Mean draft, 9 ft. 6 inches (approximate).
Maximum draft with full load,[2] 10 ft. (approximate).
Funnels, 4, except Stockton, Gwin, and Conner, 3.
Masts, 2.
Propellers, 2, except Conner and Stockton, 3.
Fuel, Oil.
Boilers, Number: 4 (Two in each fireroom).
Types: Yarrow, Normand, Thornycroft, or White-Foster.
Engines, Types: Geared-Turbines; Parsons, Curtis or Westinghouse.
Steaming Radius:
1911 to 1913 types, approximately 3000 knots.
1913 to 1915 types, approximately 4000 knots.
1916 to 1918 types, approximately 2400–6000 knots.

Development. Early destroyers in the United States Navy (*Decatur* Class of 420 tons) had a flat stern with no after deadwood, the bottom rising from about the deadflat section in almost a plane surface, so that the draft of the hull itself at the stern was only a few inches. The beam at the stern was greater than in other types and the entire above water afterbody very full. None of the United States destroyers now in active service are of this type but the effect of the features described is instructive, and as these features exist in other types of vessels, space will be taken to discuss them. The advantages of the design are two-fold: to prevent racing of the propellers and to reduce the diameter of the turning circle. In a following sea, the stern keeps close to the water, since a drop of the sea of only a few inches leaves the entire weight of the stern unsupported, so that it follows the water very quickly. In the same way a rising sea, in lifting only a few inches over the full-bodied quarter, greatly increases the buoyancy of the after part of the vessel and the stern responds immediately. The general result is that the stern sticks to the water, and racing of the propellers and the probability of pooping are reduced to the lowest degree possible with a vessel of the size.

The reduction in the turning circle results from the absence of

[1] Also 2-3″ A.A. guns.

[2] May be considerably increased when running at high speed, by the tendency for the stern to "squat."

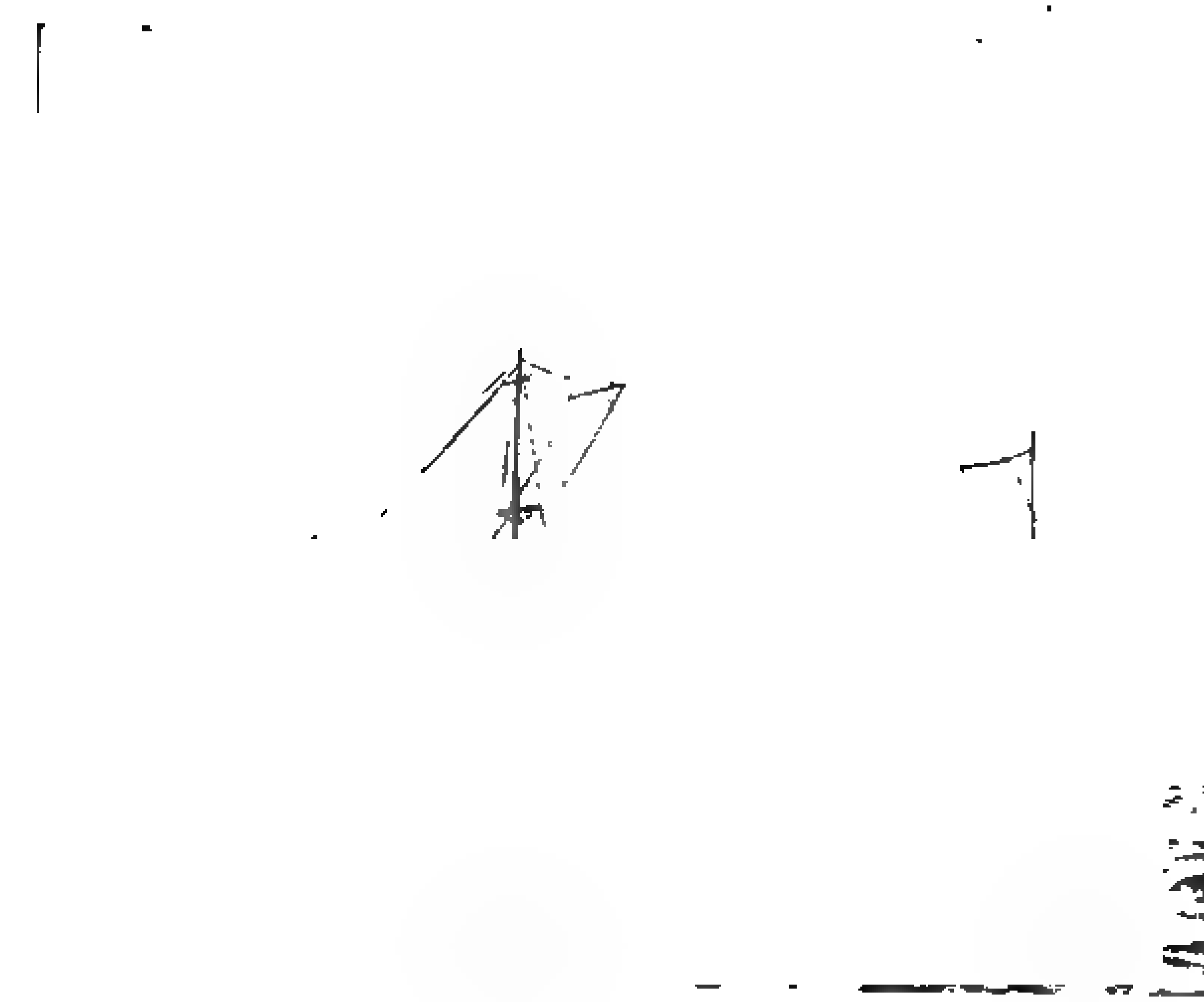


FIG. 1. HIGH BOW DESTROYER.

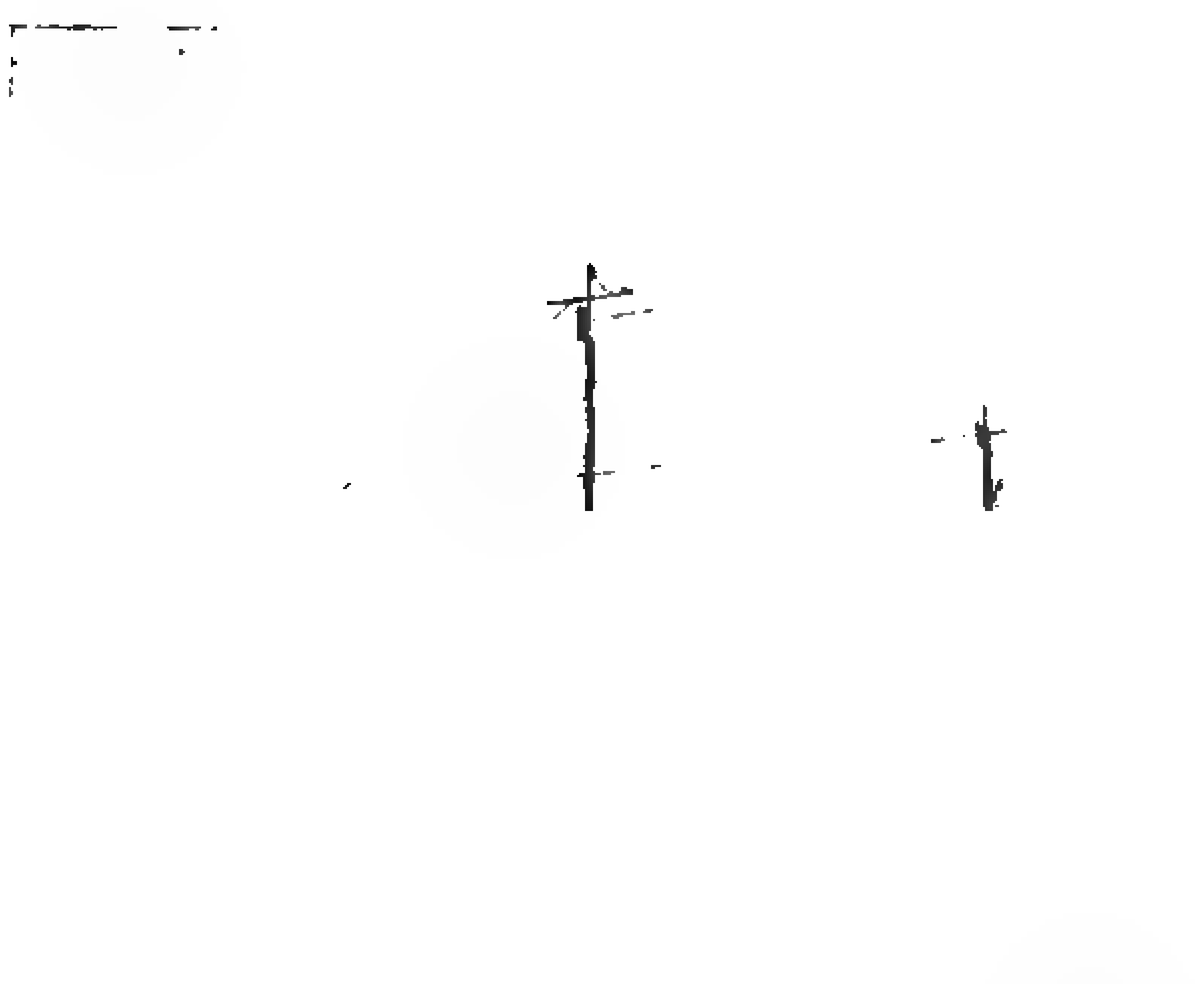


FIG. 2. FLUSH DECK DESTROYER.

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Destroyers of the
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1000-ton class, all v
ing the *Shaw*, No.

Vessels of both
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breaks off to a lo
(Fig. 1, Plate 161
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serious handicap
and allowed for,
difficult to bring
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the wind is blo
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Several narro

appreciate this feature. In turning with a vessel of this type, it is desirable to turn in such a way as to take advantage of the jib effect instead of having to work against it. The effect of the wind upon the bow is particularly important in going alongside a dock.

Destroyers of the above two types as well as those of the modern 35-knot type (Plate **162**) have a large after dead-wood, which results in greater steadiness of sea route but produces an excessively large turning circle, the tactical diameter being as great as one thousand yards with rudder angle of twenty degrees.

The later classes, 1915 to 1918, have a continuous flush main deck from stem to stern, but with considerable sheer; the bow, while less conspicuously elevated than in the earlier classes, having decidedly more freeboard than the stern (Fig. 2, Plate **161**).

The change from the high and cut away forecastle to the flush deck has produced great improvement in seaworthiness, habitability, and all around efficiency. In the flush-deck type, the reluctance to turn into the wind still exists, but in a much less marked degree; while the tendency towards excessive leeway, which is characteristic of all destroyers because of their necessarily shallow draft and the large area which they expose to the wind, is somewhat increased.

The earliest of the flush-deck type (*Caldwell, Craven, Conner, Gwin, Stockton* and *Manley*) lack the fine underwater body lines of the later vessels of their class, being decidedly flat-bottomed forward, as a result of which feature they pound heavily when being driven into a sea and list deeply when the rudder is put over at high speed.

In the latest destroyers of the 1916 program (as enlarged by subsequent legislation), the manœuvring power is increased by cutting away the after deadwood to a considerable extent and slightly increasing the rudder area. Other changes have materially added to the steadiness in a seaway, thus giving an improved gun-platform, and, by increasing the capacity for fuel oil, have extended the cruising radius.

Motive Power. Turbine engines are economical only at high speed and only at approximately the speed at which they are designed to run. This introduces two problems into the design of turbine motive power for destroyers:—first, to harmonize the high speed which is necessary for the turbine *rotor,* with the

Plate No. 162.

STERN OF DESTROYER.

lower *shaft* speed required for propeller efficiency; and second to provide for reasonable economy both at the high speed for which destroyers are designed and the comparatively low speed at which they necessarily cruise under ordinary circumstances

Various solutions have been devised for the problems outlined above and widely differing arrangements are to be found in the destroyers now in service. In recent destroyers of 35-knots designed maximum speed, a turbine speed of 2,500 R. P. M. is converted by reduction gears to 450 turns of the propeller shaft.

The problem of cruising efficiency is solved in some cases by the use of reduction gears and in others by the installation of special cruising turbines or reciprocating engines.

When a proper balance has been struck between maximum speed efficiency and cruising speed efficiency, it is found that the most economical speed at which a destroyer can cover a given distance is somewhere between 15 and 20 knots. Between these speeds, the fuel expended per mile varies but little, whereas at higher speeds it increases rapidly with the horse-power developed. Approximately twice as much fuel is required per hour at 25 knots as at 20 knots; and from 25 to 35 knots the consumption increases at an astonishing rate.

All destroyers of the United States Navy have four boilers, but it is only when making very high speed that more than two are required. A speed of 26 to 28 knots can be maintained with half boiler power, and some destroyers have reached thirty knots under two boilers. Speeds as high as 20 knots can be made with one boiler, but this is, of course, uneconomical as the boiler must be forced. Destroyers have made long cruises economically with only one boiler in use, at about fifteen knots. It is unwise to undertake harbor manœuvring under one boiler except under most favorable weather conditions, as the necessity to do considerable backing will probably draw all steam from the boiler, thus stopping the blowers and disabling the vessel.

Manœuvring. It is clear that no hard and fast rules can be laid down for the handling of destroyers any more than of battleships. It rarely happens that conditions are identical on any two occasions, even for the same vessel performing the same manœuvre in the same place. A destroyer will make more leeway when her oil-tanks are light than when she is fully fuelled. The head will fall off rapidly in making a dock at low speed if the forward tanks are empty and the after tanks full; while if the

reverse conditions exist, she may decide to lie broadside to the wind and drift bodily to leeward.

When engines are stopped and an ahead or astern signal is given, it is engineering practice to open throttles fairly wide in executing the signal, then to close them quickly to the pressure necessary for the speed demanded. Turbines of the thousand ton ships are direct connected, while those of the later type drive the shafts through reduction gears, and it is especially noticeable while warping to lines alongside docks that the newer type ships do not receive the quick "jolt" ahead or astern that is apparent with the older vessels immediately after ringing up an engine room signal. The propellers of the modern destroyer are larger than those of the older ships and they seem slower to "bite," but as soon as they take hold they are more effective so far as leverage is concerned.

In manœuvring the modern destroyer alertness and sound judgment are required. It must be kept in mind that great power is available, that headway or sternway is very quickly gathered, that the hulf of the destroyer is frail, and that in confined waters the effect of wind may be a very serious factor owing to the leeway and the poor manœuvring qualities of the vessel. The tactical diameter of the destroyer with engines going ahead and rudder hard over is greater than that of the battleship.

The effect of screws of different types upon the manœuvring of steamers is fully discussed in Chapter XIII. These effects are more or less modified in destroyers by the great length of the vessel as compared with the leverage of the screws, the result being that under the most favorable conditions the manœuvring power due to the screws is less than with vessels of greater beam as compared with length. When one engine is turning ahead and the other astern, the ship being dead in the water, it will be found that the destroyer will swing very slowly, her bow moving to the side of the backing engine. If the conditions of wind are such as to assist the bow to swing no difficulty will be experienced in turning, but if the movement of the bow is opposed by any appreciable wind, the vessel will remain stationary and merely "tremble," or may fall off, meanwhile drifting bodily to leeward.

To turn in a limited space it is well to use the engines in brief spurts of high speed, assisting with the rudder as far as practicable

and being careful not to allow the ship to gather much headway. The quickest method for turning a destroyer in a limited space is shown in Fig. 1, Plate 163, a standard manœuvring speed of fifteen or eighteen knots being assumed. The destroyer lying in position 1 and wishing to turn to starboard, starts both engines ahead at two-thirds speed, rudder full right. At position 2, or as soon as the stern has started to swing to port, the starboard engine is reversed two-thirds. The bow will swing sharply to the right, headway will be quickly checked, and the ship will forge ahead very slowly. Relative power of ahead and astern engines will vary in different destroyers depending mostly upon the pressures in use by the personnel below, but it will usually be found that in position 3 the vessel has lost all headway and will continue to swing rapidly. At this point the rudder will not be effective and may be placed amidships. If the wind is on the starboard hand, care should be taken here not to gather sternway, for as soon as the vessel starts astern, the effect of the wind will be to check the movement of the bow and to force it off. If the wind is on the port side, sternway will be helpful but if it is to be utilized the rudder should be put hard left as soon as it begins. In this case it will be well at 3 to put both engines ahead, with rudder hard right and then to back the starboard engine again as soon as the stern begins to swing.

Harbor conditions may make it necessary at position 3 to go astern, in which case it should be remembered that the rudder must be shifted to left as soon as sternway is noted.

In the above example a speed of two thirds ahead and astern is advocated. Weather conditions frequently necessitate the use of higher speeds to expedite the turn and this is always available, but most destroyer officers prefer to employ *full* power *astern* sparingly because of the great volume of steam that this so suddenly draws from the boilers.

In narrow waters, under adverse conditions of wind and tide, two or more destroyers may be secured together and advantageously manœuvred as one vessel. Opportunity offers employment of this method when destroyers, moored to the same buoy or dock, are scheduled to sail simultaneously or to shift berth or enter a slip, tide or wind being unfavorable to single manœuvring. Very delicate control can be maintained in this manner, as the leverage of the screws is considerably multiplied, only outboard engines being worked, while the wind surface

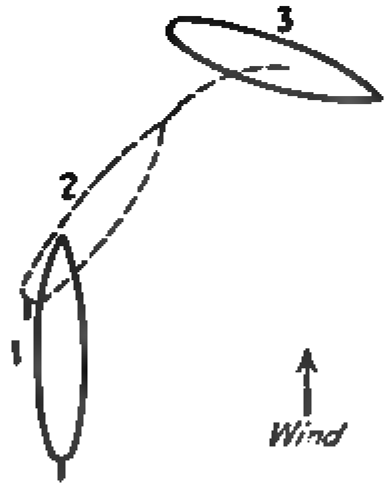


FIG. 1.
TURNING IN A LIMITED SPACE

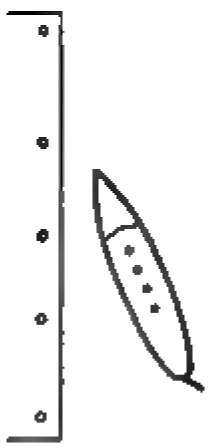


FIG. 3.

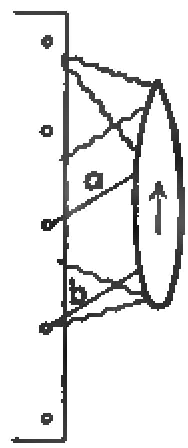


FIG. 4.

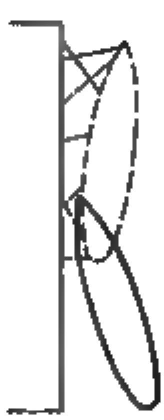
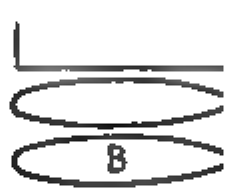


FIG. 6.



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is not materially increased over that of the single vessel. Precautions to be observed are to see all lines doubled and taut and to use little power. As many as four destroyers have been manœuvred in this manner, one officer, of course, doing the conning. Fig. 2, Plate 163.

To pick up a buoy, approach on the weather side at slow speed and, if a boat is not in the water, lower a man to the buoy by means of a bowline from the forecastle. It is advisable to lower a boat to expedite the work of securing and to avoid possible injury to personnel. Little difficulty is usually found, by skillful use of engines and by taking advantage of wind, in keeping the ship in position long enough to enable the man on the buoy to make fast a line, after which the end of an anchor chain is led through the ring of the buoy and made fast on deck.

The facility with which destroyers can be handled when going astern, especially when backing into wind or current, may in some cases render it advisable to make landings or enter slips stern first. With gentle sternboard, motion of one screw astern will ordinarily push the stern away from the side of that screw and delicate control is often possible under these circumstances. A special case in which this method of handling is recommended is when running into port with following wind or current, when it is intended to pick up a mooring buoy. Rounding to under these circumstances will be a long and troublesome operation, especially if the channel be narrow; and under these conditions the bow may be run up to the buoy and held there indefinitely with stern to wind and tide by skillful backing of first one engine and then the other.

One destroyer commander is said to have been very successful in manœuvring through crowded harbors by backing both engines and by use of rudder, at the same time trailing an anchor as a drag on the bow.

Going Alongside a Dock. The destroyer officer gets constant practice in making docks under various conditions of wind and tide. The discussion in a previous chapter of "Handling a Steamer Alongside a Dock" applies to destroyers as well as to other vessels, but with some points of difference. The lightness of the ship, the large surface which she exposes to the wind, and the comparatively small draft, give exceptional importance to the effect of wind, especially if this be on the beam.

As discussed in a later chapter on "Keeping Position and

keep constantly in mind the effect upon manœuvring which results from the limited backing power of turbine ships in general; the power available for backing being but little more than half of that for going ahead. This condition holds for destroyers except that the power available for backing is ample and satisfactory when compared with the power that will *ordinarily be used ahead* in approaching a dock. However, if considerable headway is gathered the backing engines are slow to take charge; and if excess speed ahead is used in making a dock or in entering a slip, an error in judgment as to backing may have very disastrous consequences.

Destroyers are light craft with very powerful engines and there is an easily understandable fascination in handling them which frequently leads to the taking of unnecessary chances. A good destroyer officer is one who uses the powers at his command daringly when necessary, but who does not invite disaster by rashness. It happens from time to time that an engine will not follow the signal, through fault of either personnel or material; and if this happens when the commanding officer is charging into a landing at high speed, trusting to his backing power to stop in time, the result may be a smashed bow or some worse accident, resulting not from an effort to perform some important service, but merely from bravado.

The light scantling and high power of the destroyer make it especially important to exercise care in warping or springing around docks. If the fact be kept in mind that the horsepower of the latest type destroyer is equal to that of a 32,000-ton battleship, and that the hull is at the limit of lightness, it will at once be realized that the engines can only be worked against chocks, cleats, etc., with extreme care. This caution applies not only to the fittings of the vessel itself, but to the lines by which she is to be handled. The largest mooring line with which destroyers are at present equipped is a 5-inch manila, and this is none too strong. The foregoing should not be taken to mean that power cannot be employed while springing the vessel on a line, as it is often necessary to work the engines in opposite directions at considerable speed. What is meant is that great strain cannot be brought on the line by imparting motion to the vessel.

The speed to be used in approaching a dock should be in

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position of the vessel relative to the dock making it impossible to throw the stern either in or out.

When the wind is blowing onto the dock it is best to approach parallel but well clear—just within heaving line distance. As the destroyer loses headway she will drift easily and bodily in to the dock. The backing of the outboard engine will offset the tendency of the bow to drift more rapidly than the stern, and the engines may easily be manœuvred to keep the ship squared off with the dock face. This landing affords good practice for the beginner, for he may approach well clear and at his own speed and cannot miss eventually making the dock.

When the wind is blowing *off* the dock it is often necessary to use greater speed and to approach boldly, owing to the rapidity with which the destroyer drifts to leeward as she loses her headway. In this it is safe and best to begin the approach as if to make a parallel and close aboard landing. As the dock is neared the effect of the drift will be felt and the rudder must be used to point the bow very close in, and this will result in a cant towards the dock. As soon as it is assured that a position will be reached from which the bow lines can be cast, the rudder should be thrown away from the dock and the outboard screw backed in order that stern lines may be got out. It is now important to remember that the destroyer pivots just abaft the bridge, that there is a capstan forward but no winch aft, and that the heavy stern can be brought to a securing position only by use of engines and springs. The wind being off the dock, bow lines should be run as quickly as possible but should immediately be slacked to avoid a strain forward and to permit the bow to fall off as may be necessary in order that the stern may be brought in smartly by engines and rudder. Bow lines once being passed, the bow can always be warped in by means of the capstan after the stern is in the position desired.

To breast the ship in, the waist line can be depended upon and it is important that this line be got out quickly. The waist line should be the stoutest of the mooring lines and should be not less than forty fathoms in length. It is led from a chock slightly abaft the pivoting point. The ship can be sprung in on this line by forging ahead or astern, using engines and rudder to best advantage, but the strain must be watched carefully, as the line is usually of five-inch manila and is easily parted. A stern spring may be used to assist the waist line, as shown in

Fig. 4, Plate 163, when forging ahead. When forging astern a forward spring may be added to these (Fig. 5). All slack of waist and stern lines should be taken up with each effort. Some destroyers are equipped with flexible wire mooring lines, mostly 5/8″ diameter, and such lines are allowed all vessels; but there is a difference among officers regarding the desirability of substituting wire for manila for mooring purposes. Wire is less bulky and consequently more readily stowed; it does not require being dried out on deck after having been wet; and it is of undoubted value when the vessel is to be secured alongside for considerable time or when strong currents are running or heavy winds blowing. The disadvantages of wire are that it has not the spring of manila when subject to sudden strain and that men are loath to handle it, owing to the fact that when worn or slightly stranded it tears the hands.

If the wind off the dock is very strong, some officers make the landing as shown in Fig. 6. As the dock is neared the inboard screw is not stopped but is kept turning one third ahead. At position 1 the rudder is thrown right and the outboard engine backed full speed, thus bringing the stern in against the wind with considerable leverage. The ship will bring up as in position 2, from which it may be warped in. This method is especially useful when the tide tends to keep the stern out, as when the dock is entirely or partially athwart the stream.

Various conditions of tide are encountered, and an officer having to work habitually around a certain locality will in time become accustomed to the peculiarities of the currents; but much time and trouble may be saved by making a study of those peculiarities from the first, through systematic observations of the strength and direction of the current from hour to hour through several days, keeping a careful record and referring all hours to the time of high and low water as given in the tide tables (see remarks on this subject in chapter on Piloting). It must be kept in mind that currents are often baffling around the face of a dock and that the surface current may be running quite differently from the main current of the stream.

When the tide is running strong and parallel or nearly parallel to the dock, the wind may be considered as of secondary importance, for the destroyer is long and narrow, and when placed at an angle from the axis of the current will rapidly be carried towards or away from the dock depending upon that angle. If

in this case the landing is to be made ahead of other vessels, care must be taken to approach well clear in order not to be carried down across the bows of those vessels (Fig. 7). "A" approaches boldly at a slight angle to the axis of the current and well clear of "B." When his stern clears "B's" bow, "A" backs his outboard screw slowly, with right rudder, and is straightened out and brought to the dock by the combined effect of tide, rudder, and engines.

If the tide is forcing the vessel on to the dock, as will often happen where docks are athwart the stream, it is important that engines be manœuvred to keep squared up with the dock as the vessel drifts in with the current, and to see that sufficient fenders are ready in place, otherwise serious local damage may be caused to the shell plating.

If the tide is running away from the dock, speed must be used, lines must be got out smartly, and backing power and good judgment depended upon. Once the lines are out, the stern must be brought in by springing upon the waist line and by skillful use of engines and rudder.

To make a landing with a fair tide is very difficult, as the slightest cant towards the dock will bring the current under the inboard quarter. This force will probably overcome all effort of engines and lines to bring the stern in, especially if strain be brought on a forward line, which is an error commonly made (every destroyer officer learns that it is useless to attempt to spring in on a bow line). The ship should be brought as nearly parallel to the dock as possible, preferably with a slight cant outward, and the after lines got out smartly and held. If a line can be secured aft it will act as a spring, and the current will bring the ship in readily. The bow will take care of itself. It will ordinarily save time, with this condition of tide, to turn and stem the current or to drop an anchor and swing before approaching the dock.

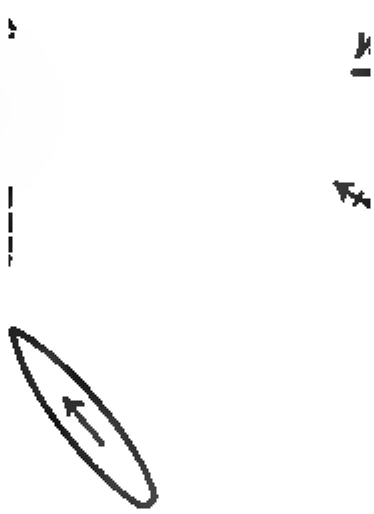
It has been said that backing power relative to ahead power is not uniform in destroyers. The speed at which a dock should be approached is further modified by the meaning of "stop" as construed by the engineer officer. With reciprocating engines the propellor stops with the machinery; but when turbine throttle valves are closed, the ship having headway, propellors will continue to revolve, turning the rotors in vacuum. Many destroyer officers give instructions that when "stop" is rung up

sufficient steam shall be admitted to the backing turbines to actually stop and hold the shafts. The choice of method is not mandatory but the officer conning should have an understanding with the engineer officer as to the system to be used, because, when the shafts are held, the dragging of the propellors considerably checks the headway of the ship. It is more economical from an engineering standpoint to close the valves and permit the shafts to turn idly but in this case a slightly increased interval is required to execute a backing signal; whereas if the shaft be held, the astern throttle is already partially opened before the backing signal is received. From the point of view of seamanship the method to be chosen depends much upon what one has been accustomed to. In making a dock there is of course a feeling of confidence, when the shafts are held by steam through the astern throttles, that the backing signal will be quickly and certainly executed.

Going Alongside a Vessel at Anchor. This is very similar to going alongside a dock except that conditions of wind and tide to be met are usually more favorable. The destroyer must keep clear of an overhanging stern or of any projections from the side of the vessel approached and if possible select a part of the ship's side where there are no projections; for a whaleboat, an ash chute, or a triced up gangway may inflict serious damage to the destroyer's upper works. The greatest danger to be avoided is that due to the possible yawing of the vessel at anchor and this is especially to be guarded against if the vessel being approached is a destroyer, for these craft yaw very freely when anchored and riding to wind or tide. Just as the lines are about to be passed, after an approach that has looked perfect, the stern of the anchored vessel may swing so unexpectedly as to make it impossible to avoid a sideswiping blow. A destroyer riding to a long scope of chain yaws excessively from the effect of the wind on her high forecastle and her bow may fall off as shown in Fig. 1, Plate **164**, when she reaches the end of her arc. If this happens, the vessel going alongside may find her stem unexpectedly brought up against the side of the other destroyer, or her projecting anchor may "sweep the rail" of the vessel anchored.

NOTE. See description in Chapter XI, § III, and Plate 97, of proposed method to prevent yawing.

Plate No.



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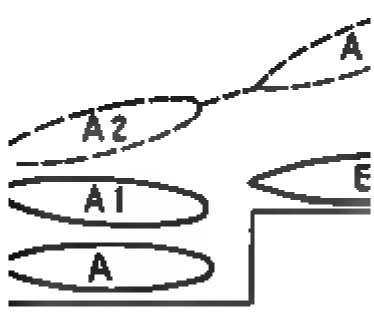


FIG. 3.

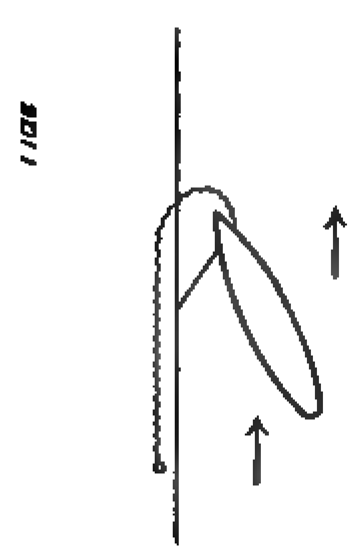


FIG. 6.

;IDE AND LEAVING

There is really no difficulty in going alongside a vessel at anchor and the fact that she is at anchor makes it reasonable to suppose that there will be ample manœuvring room, except when she rides with her stern close to the beach; hence caution, not high speed, is all that is required. The approach should be made fairly well clear with a slight cant inward, and the stern should be brought in and the bow carried out by backing the outboard screw and by use of rudder as forward lines are passed. Here a spring leading forward from the after forecastle chock of the destroyer can be held and the ship breasted in easily by the current, a breast or bow line through the bull-nose being hove in as necessary by means of the capstan. *Unlike the situation in going alongside a dock, the forward lines are the more important,* for the stern will be taken care of by the wind or current to which the anchored vessel is riding and engines and rudder can easily be used to assist in paralleling the two vessels as they draw together.

If the wind or tide is very strong the destroyer may be brought up well clear and, if not within heaving line distance given a slight cant across wind or tide. By slight assistance from the engines *and rudder* she will then gradually drift over until forward lines are passed and may be brought alongside parallel and without shock. If she tends to cant too much, bow lines must be slacked before control is lost, and inboard screw worked ahead and outboard screw astern, with rudder thrown away from the anchored vessel in order to prevent the bow from coming in too rapidly.

Should the vessel ride at anchor so that her stern tails close to the beach, it is sometimes feasible to make the landing stern first, but if the wind is blowing very strong this should not be attempted. It is here that an anchor may be used to advantage (Plate 164, Fig. 2). "A" approaches with the wind as shown and drops an anchor off the bow of "B" at position (1).

The anchor is held under foot—and chain veered if dragging is noted—until the destroyer swings to the wind. Forward lines are now passed, dropping down by veering chain if necessary, and when these lines are secured on B's deck A may heave up her anchor and warp alongside by means of a forward line, assisted by engines and rudder.

While alongside a dock lines are doubled up and secured, care being taken that all lines are sufficiently slack to allow for

rise and fall of tide. This precaution is necessary with all classes of ships, and there is a record of at least one steamer having been sunk by failure to observe it. An army transport at Shanghai, where rise and fall of tide is about 18 feet, was listed over by her lines, permitting water to enter her portholes and sink her.

It might be stated here that destroyers have sustained and inflicted serious damage alongside docks from the following causes.

1. Improper method of warming up engines, resulting in jammed open throttle, parted lines, and damage to dock and ship. Precautions against this are covered in the Engineering Manual.

2. Engine room signal improperly executed on leaving the dock. If one third astern is rung up and one third ahead delivered by untrained personnel, it is best to *stop* immediately and take light punishment; for if the telegraphs are rung "full astern" when this mistake occurs the probability is that "full ahead" will be received.

3. "Jingling of telegraphs followed by 'stop'" as a signal for the engine room to secure after the vessel is moored. This is bad practice; for in cases where the telegraph has carried away in this operation, the pointer has rested on full ahead. Little time is required to deliver the message "Secure" by voice tube or messenger.

Getting Clear of a Dock or Vessel. Lines are singled after engines have been reported ready. Advantage should be taken of wind or tide to start either bow or stern out, and these should be assisted by stern or bow springs. If there is no wind or tide and it is desired to back away, hold a bow spring and go ahead gently on the outboard screw until stern has begun to swing out, then cast off and back clear. If desired to go ahead, back slowly on the outboard engine, holding a stern spring and being careful not to endanger the inboard screw.

If the wind is holding the vessel on the dock the first precaution to be observed is to place the anchor on deck, as destroyers carry old fashioned anchors with fluke projecting from the billboard. It is then best to go ahead slowly on the outboard engine sufficiently to keep a strain on a bow spring, if necessary assisting the stern out by backing the inboard screw. As soon as the stern is pointed clear, put both engines astern

with plenty of power, harbor conditions permitting, in order to gather headway quickly. Place the rudder over towards the dock or away from the wind and stop the inboard engine. The backing engine on the windward side, combined with the effect of the rudder as headway is gathered, will overcome the tendency of the stern to point into the wind and thus prevent the bow from falling off against the dock. It will sometimes be necessary as the ship starts astern to go ahead on the inboard screw to assist in keeping the bow clear.

The means employed in getting clear of a dock must conform to harbor conditions and weather but in difficult situations the possible use of lines should not be overlooked. The use of lines and anchors will not be despised by anyone who has watched harbor masters manœuvre strange vessels in crowded waters and warp them into difficult slips.

The destroyer "A," moored as in Fig. 3, Plate 164, and wishing to clear the dock, can be assisted by a line run to the stern of the ship D or to the mooring buoy C and taken to the capstan. If the wind is blowing as shown, A has only to run a line to the stern of D, cast off from the dock, and ride to her line until she reaches the position A-1, taking in on the line sufficiently to keep her stern clear of the dock. Engines may then be manœuvred to force the ship's stern into the wind as at A-2, when the line is cast off and the ship backed out of the harbor. Once sternway is gained the destroyer will answer her helm across the wind if sufficient power is used.

No difficulty should be experienced in clearing from alongside a ship at anchor, for the anchored vessel will ride to wind or tide and if there is no wind or tide the procedure is the same as when leaving a dock under the best of conditions. With wind or tide, forward lines should be cast off and the destroyer held by a stern spring. The bow will fall off gently and if the inboard propeller guard should be brought against the ship's side it will be without shock or damage. If a strong tide is running, the outboard screw should be put ahead slowly to keep the stern clear and as soon as the bow has fallen off sufficiently, both engines should be put ahead, with rudder over *towards* the anchored ship. This will keep the stern clear, and the large turning circle of the destroyer will eliminate all danger forward. If the vessel which is to be cleared from is a destroyer, the engines must be worked ahead slowly as the bow falls off, to avoid any

possible damage aft; for unless the two vessels have equal draft, the propellor guard of one may ride over that of the other, locking screws that are very easily bent.

Winding a destroyer on a line is very easily accomplished when wind or tide is favorable; and this manœuvre is often of great value when the tide is wrong and it is desired to leave a narrow harbor. In such harbors several destroyers are frequently moored to the same buoy, as in Fig. 4, Plate **164**. *A* casts off forward, his bow falling off as strain is brought on the after spring. He then works his inboard engine ahead sufficiently to keep his stern clear of *B* and swings with the tide until so pointed as to be able tó cast off his stern line and proceed. In very narrow waters it may be advisable to run a second line from the off quarter, taking strain on that line when the vessel is athwart the stream; and in any case it is well to have this second line as a preventer. When winding in this manner with a strong tide, the line must be cast off at just the right time and the signal for this is usually a short toot of the whistle. This evolution is also commonly used in clearing a dock under the conditions noted above.

The necessity for winding at a dock is often felt when a destroyer is moored in a narrow harbor or at a river dock, pointed up stream, and is required to sail at an hour when the tide will be running flood. If she waits until the hour of sailing to get pointed downstream she may be delayed by some unforseen circumstance, or may find that a strong wind may hold her on the dock and make turning very difficult. She should, at some time previous to sailing, take advantage of an ebb tide and a favorable wind to wind ship and get pointed down stream. (Fig. 5, Plate **164**.) A destroyer so situated holds a stern spring and permits her bow to swing out as shown, then goes ahead with rudder over away from the dock until she reaches position (2). Here a spring which has been led well up the dock from the off quarter is taken in and held, the inboard screw being worked ahead when necessary to keep her stern clear of the dock. The current will now bring her around and when position (3) is reached the spring may be slacked and the engines manœuvred to bring her stern far enough up and clear of the dock to permit the bow to come in to the position required for mooring. The time to be chosen for this manœuvre should if

possible be when a light wind is blowing off the dock and when the ebb is running slowly.

A few destroyers are fortunate enough to have had winches installed aft. These are of assistance in mooring and are very effective in winding at docks. In the example above, a destroyer having a winch aft can be wound in a narrow channel regardless of harbor conditions ahead, by holding a stern spring and taking a spring from far up the dock through a chock on her off quarter and to the winch. As her bow swings out with the current, she heaves in on the off spring using engines to keep clear; and, when the turn is partly made, to bring her stern to the proper position up the dock.

Winding on a bow line is also possible, the inboard screw being backed to keep the stem away from the dock as the stern is carried out into the stream (Fig. 6, Plate 164). A line from the off bow is led around the stem and well down the dock, and strain is taken on this as the vessel comes athwart the current. If a strong tide is running it may be necessary, as the turn nears completion, to slack the bow spring so that engines can be manœuvred to overcome the cant across the tide, keep the bow clear of the dock, and straighten out the ship. It may even be necessary to drop an anchor to assist in this manœuvre. If it is intended to sail on completion of winding, it is quicker to cant the stern out by means of a forward spring, back off, and drop and swing to an anchor, veering chain and going ahead towards the dock if the harbor is so narrow as to make this necessary.

At Sea. The destroyer is so light in proportion to her size that she acts at sea much as would a floating plank if driven through the water at some speed. Rolling is very heavy at times, depending upon the angle at which she takes the waves, but when the sea is abaft the beam the vessel seems to rise and fall without excessive motion, without shipping water, and with surprisingly little jerk at the end of the roll. In a long storm sea, by bringing the sea abaft the beam and regulating the course and speed as is found desirable (see chapter on Handling Steamers in Heavy Weather) the vessel will ride very easily and if properly handled should weather any storm.

As previously stated, the destroyer at high speed will "squat," the screws drawing down her stern so as to materially increase the draft aft. This squatting is greatest at a speed of about twenty-eight knots; and, curiously enough, as the speed is

increased beyond this she tends to right herself until at top speed she carries very little drag. This is true only in deep water; for in shallow water the drag on the bottom is so great that a speed of 28 knots cannot be made.

Every destroyer has two "critical speeds," usually at about ten knots and again between twenty and twenty-two, and at these speeds a certain amount of vibration will be felt. At all other speeds, if engines and shafts be true and propellers undamaged, the vibration is almost imperceptible.

With the sea ahead or forward of the beam, both rolling and pitching may be very heavy; and when steaming into a head sea much water is often taken over the bow.

Bucking a head sea is the most trying effort a destroyer can be called upon to make, and troubles may be met even at comparatively low speeds. These troubles are not necessarily dangerous to the destroyers of to-day, which are strong capable vessels vastly different from the type of twenty or even of ten years ago. The late war has shown that they will stand a great amount of punishment,[1] but they should not be subjected to such punishment unnecessarily.

If forced, they will often ride smoothly over several waves, then rise forward and pound heavily, submerging the bow and shipping green water in such quantities as to damage the upperworks.

The destroyer's quick period makes a short steep sea more trying than any other and if *forced* into heavy weather in partially enclosed waters such as Long Island Sound she may pound more heavily and suffer more damage than under the same weather in the open sea, where the waves are longer and where the vessel will seem to slide over the crests. During the war an escort of five destroyers had to abandon their 22-knot convoy, the *Mauretania*, between Liverpool and The Skerries, where short high seas were thrown up by the wind ahead; and three

[1] *Cassin's* stern was blown off by torpedo, and *Manley's* stern to after engine-room bulkhead was destroyed by explosion of 30 depth charges. Both were towed to port without difficulty. Several destroyers sustained severe damage from collision and all returned safely. The *Shaw*, whose bow was completely severed at the forward end of the bridge by S. S. *Aquitania*, made port under her own engines, her forward oil tanks on fire. All American destroyers stood up splendidly so far as damage from seas was concerned and proved that they can operate in the worst weather.

of the escort returned to port with their pilot house bulkheads crushed in.

With the sea aft or on the quarter, the vessel rides very easily, with little rolling or pitching, and no difficulty is experienced except in steering.

In formation underway, the standard distance between ships, bridge to bridge, is 300 yards; and it is safe even at high speeds to keep well within this distance, for collision can easily be avoided by quick use of rudder. However, with a following or quartering sea it is unwise to manœuvre too close, for under these conditions the best helmsmen cannot steer a steady course and the bow as it yaws from side to side may strike the stern of the destroyer ahead before the rudder can become effective.

When lying-to in a seaway, the destroyer will invariably work broadside on, into the trough,[1] rolling heavily and drifting rapidly to leeward. If she is backed from this position, her stern will tend to point up; but the quantity of water shipped over the stern will prove very dangerous.

Because of the number of destroyers employed on the same mission, it is often necessary for these vessels to be anchored in outer harbors where little or no protection is afforded.

Sometimes, as at Ponta Del Gada, the anchorage must be close in shore because of the fact that deep water extends very close in and the anchorage is exposed to wind and swell from the open sea. A long scope of chain must be used; and with the present ground tackle arrangement there is danger that the chain will be parted or weakened as it is nipped across the sharp stem by the excessive yawing of the vessel. In getting underway from such an anchorage, if the sea is running directly towards the beach, the engines must be started ahead promptly and with power, as the anchor breaks ground; otherwise wind and sea will force the bow off into the trough parallel to the shore line thus placing the ship in a very precarious position. As the chain is being hove short it is well to avast heaving when the chain tends off the bow due to yawing, for there is danger here that the anchor will begin to drag, placing the vessel broadside to a lee shore and in the trough, not free to go ahead. To avoid

[1] So strong is this tendency to lie in the trough that a destroyer attempting to save the capsized seaplane NC-1 in a severe storm and having succeeded in getting a 5-inch line from her bow to the plane in the hope of using the plane as a sea anchor in riding out the night, could not be brought bow to sea. The line parted though strain was taken cautiously.

this possibility the chain may be held until the yawing of the ship points her directly into the sea, at which time it is hove in rapidly and engines put ahead. The rising of the bow with the crest of a wave may at any time break out the anchor, so that it is good practice when at short stay and pointed fair to start engines ahead, dragging the anchor into deeper water and heaving in as soon as the windlass will take the chain.

In case of man-overboard it is quicker to stop the ship by backing full speed as soon as the stern clears the man, then lower a boat. When the sea is rough it is better to pick up the man with the ship, turning with hard over rudder. The time to turn is considerable, owing to the large turning circle, but the ship will return almost exactly to the spot where her rudder was put over and by stopping to windward the destroyer will quickly drift down upon the man, making a lee for him and enabling him to be picked up by line or by lowering a man in a bowline.

To pick up a boat, the destroyer should be brought to windward and permitted to drift down. The ship will make a satisfactory lee for the boat and the principal precaution to be taken is to see that the boat does not get so far aft as to be crushed beneath the propellor guard as the destroyer rolls. If the boat is to be hoisted in, she must be held off while being hooked on, in order that her gun-whale may not get caught beneath the guard rail; for the boat will be jammed tight against the destroyer by the leeway being made by that vessel. During the War many survivors in open boats were picked up by destroyers under very severe weather conditions, and despite the heavy rolling of these vessels there is no record of a boat having been capsized or a life lost in so doing. When we entered the War destroyers were outfitted with special ladders for rescuing survivors from boats, but these were discarded by most destroyers as it was found that "The survivor always gets aboard."

Navigation. Although not properly belonging to the subject of seamanship, a few cautions as to the navigation of destroyers may not be amiss.

As already mentioned, leeway, real or apparent, must be carefully watched.

The compass card oscillates considerably in a seaway, introducing errors due to heeling and to difficult steering. Large changes in deviation may result from slight repairs or alterations to the ship, so that the ship should be swung frequently for

compass error, and azimuths should be taken daily at sea. Most cruising is done at fairly high speeds so that a slight error in compass course, under weather conditions adverse to observation of sun or stars, will result in large error in the position by dead reckoning. Most destroyers are equipped with the Sperry two-wheel gyro compass, but little dependence can as yet be placed on the gyro in this type of vessel. Unquestionably the gyro compass will in time be developed and made suitable for destroyer work.

The motion is at times so excessive that it is difficult to use navigational instruments, and the navigator must learn to take sights while holding on to a stanchion or bridge rail to keep from being thrown from side to side, at the same time endeavoring to keep his sextant mirrors free from spray. He must become accustomed to "bringing down" stars under conditions of most violent rolling and learn to eliminate errors due to a rapidly changing dip, and to plot his positions with instruments that are constantly getting adrift.

The use of the hand lead is very difficult owing to the low position of the leadsman and to the relatively high steerageway speed of the vessel; and although the lead must be used for in-shore work, in accordance with Navy Regulations, it cannot be relied upon unless the vessel is almost dead in the water. Destroyers are all provided with sounding machines for deep sea work and can get good soundings by slowing down.

The rates of chronometers are liable to change owing to vibration and excess motion, and the navigator should take a tick frequently.

To summarize: although it may justly be said that practically all methods of navigation are less reliable on Torpedo vessels than on larger craft, the navigator can with diligence and practice overcome these difficulties; and it has been demonstrated that destroyer navigation can be made to compare favorably with that of the largest vessel. Skillful navigating in destroyers is of the utmost importance because of the duty required of these vessels. In scouting work and in trailing the enemy, contact reports and other information sent out by the scout may be very misleading to the commander-in-chief unless based upon the most accurate navigation.

In Narrow Waters. In entering harbors, speed must be reduced to not more than fifteen knots because of the stern

wave that is drawn by destroyers in shallow water. At high speed, in depths of forty feet or less, the screws draw down the stern causing the vessel to drag and to be materially slowed. This drag is very perceptible and the speed of the vessel through the water cannot be increased above a certain point (about twenty knots) regardless of the speed of the screws. The stern will squat until the fantail deck is flush with the surface of the water, and the resultant wave will prove very destructive to harbor craft, and even to sea-walls and large shipping. So many complaints have been received and so many bills submitted to the government for parted lines and damaged property that present orders prohibit destroyers from using a speed greater than twelve knots in entering and leaving harbors. For this reason many units of the flotilla make it doctrine to use a standard manœuvring speed of eighteen knots. Channels are entered and left at two thirds speed, or twelve knots, and all speed signals except cones are thus eliminated in getting underway and coming to anchor. It is unsafe to pass operating dredges at more than six knots.

In rounding bends in rivers or narrow harbors it must be kept in mind that the destroyer pivots well forward, her stern being thrown away outside the course. Care must therefore be taken that the stern is not endangered. It is well to remember also that if the rudder is put over towards an obstacle which the bow has already passed, there is no further danger from that obstacle except of course where strong currents are involved.

In rivers, deep water is to be found on the side of the high bank, and it is safer to round a sharp river bend with fair tide than when stemming the current; for often the engines have to be manœuvred separately, with consequent loss in headway, in making such turns, due to the destroyer's large turning circle. Slack water is of course to be preferred at these bends, but if the vessel is stemming the tide, the bow will be thrown off by the current and the vessel may easily be shoaled before control can be gained; whereas with a fair tide the current on the quarter tends to assist the turn and the movement of the bow is not impeded (see Chapter XVI and Plate 136). Furthermore, if the ship should be grounded in turning it is probable that she will not strike stern first, as this presumes that her bow was at some time pointed clear and that the speed available could have been employed to send her ahead out of danger. If unable to

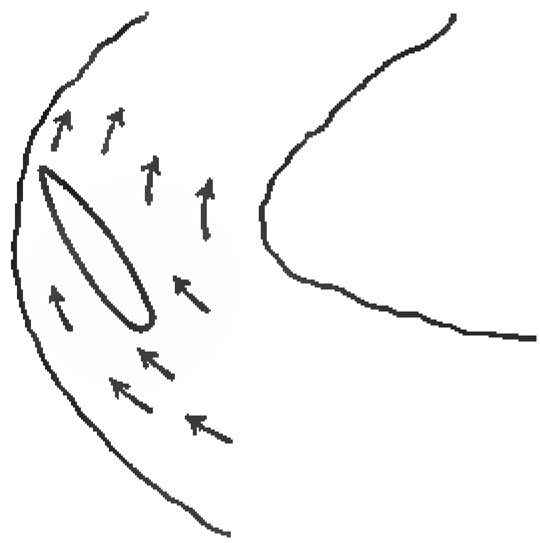


FIG. 1.

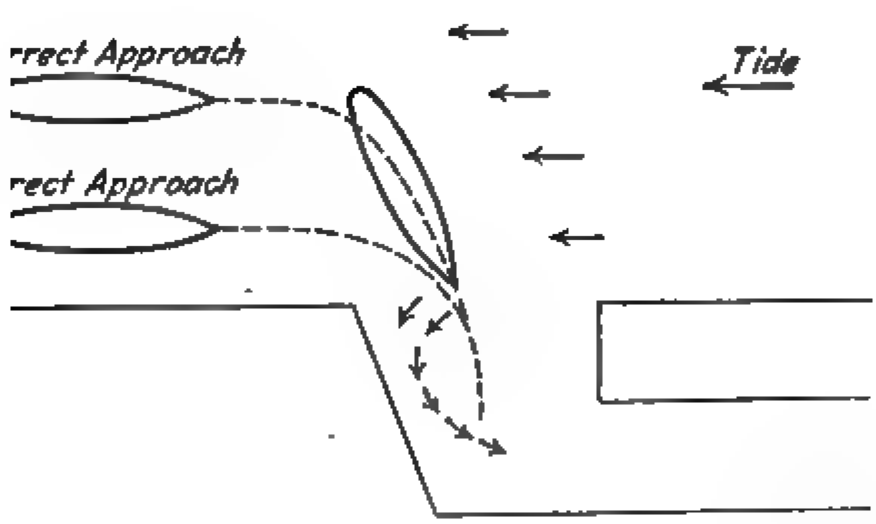


FIG. 2.

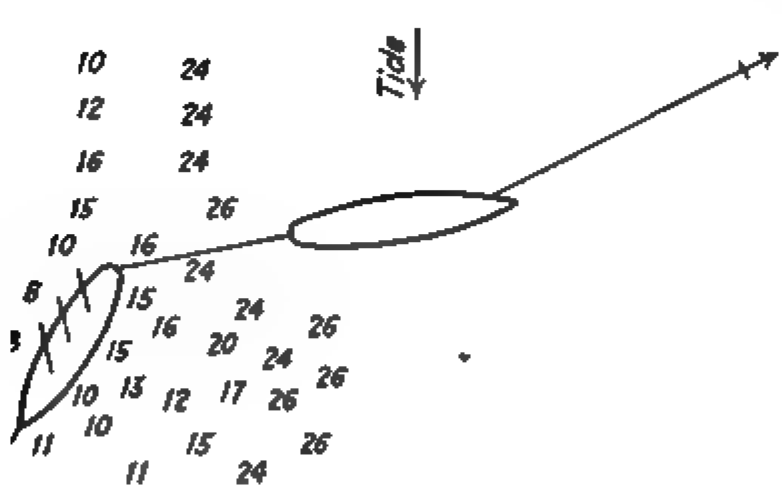


FIG. 3.

HANDLING DESTROYERS

make the turn, and forced to drift with the tide, she may be carried safely through; but if her bow should go aground, the current under her inboard quarter will tend to force her off with great force, and she may come off unharmed, around the bend and once more under control (Fig. 1, Plate 165). Low speeds must necessarily be employed in rivers and it is advisable to approach sharp turns at one third speed until just before the turn is to be made, then to go standard ahead both engines with hard-over rudder, backing the inboard screw as soon as the stern begins to swing.

When leaving narrow waters that open into seas where strong tides may be expected to run across the entrance, do so with caution and see all hands clear of the forecastle. The sea outside may not look extremely rough; but at times, on entering the junction of the two waters, an unexpected wave will sweep the forecastle. This is a bad place in which to be engaged in securing anchors for sea. Two destroyers have recently passed through this experience, one off Tampico and one outside of Brest, with serious injury to personnel in one case and loss of life in the other.

In entering slips and making landings, the effect of eddies in the current must be studied; for the destroyer is long, and when her bow enters dead water or an eddy, the effect of the current on her stern may endanger the vessel. These conditions may be encountered in entering the New York Navy Yard (Fig. 2, Plate 165). A strong tide may be running in the East River and on passing the pier line and entering the basin an eddy will be found running in the opposite direction. The bow, on entering this, will be swept sharply to one side while the outside current will carry the stern to the other, and at least one collision has occurred in this manner to the surprise of a destroyer commander. In entering the basin at New York Yard, it is best to stand up the East River channel close to the Brooklyn shore, stemming the tide and to turn sharply, rather than get across the current of the main tidal stream.

In passing through Hell Gate much traffic is often met, and this usually consists of tows. The tugs, making barely sufficient speed to keep their barges in motion, choose a fair tide, and are compelled to head directly across the stream in order to keep their tows off the rocks at the turns; and it will sometimes be found that they completely block the channel. Here it is best

for the destroyer to have a fair tide; for the speed of the tows is less than steerageway for the destroyer, and the latter vessel cannot use her speed at the turns and must partly drift through the gate, using her engines in brief spurts to make the rudder effective and to keep off the rocks.

Caution must be exercised in heaving-to in narrow waters, owing to the rapidity with which the destroyer will fall off and drift with the effect of wind. The precaution "Have one anchor ready for letting go" probably applies more seriously in destroyers than in any other type of vessel. If caught in a tight place, always manœuvre to keep the stern in deep water. If the ship should be grounded forward it is probable no damage will result, and she may be able to work off without outside assistance. But if the stern be grounded, it means a dry-dock job, for the propeller blade tips extend about nine inches below the keel of the vessel and will invariably be damaged.

Towing. The method of passing lines and taking vessels in tow is very fully described in Chapter XXV. Destroyers are not constructed for the purpose of employment in towing, but are at times called upon to engage in this heavy work and are capable of performing it. To this end all destroyers carry a 150-fathom eight-inch manila hawser, on a reel protected from the weather at the after deck house. Around the bases of the forward and after gun-mounts a channel-bar ring is shrunk for the purpose of securing lines or bridles; and towing bridles of 1⅝-inch wire are provided, completely equipped with shackles and pelican hooks. Lines for towing or being towed are led through large chocks at stern and bull-nose respectively.

In passing tow lines it must be remembered that the destroyer drifts more rapidly than other vessels and lines may be passed by proceeding to windward on a heading parallel to that of the vessel to be taken in tow and drifting so as to pass just clear. If weather conditions permit, the destroyer may be backed up into wind and sea until the first line is run. It is of course advisable not to attempt to back after the tow line has been passed. When a heavy sea is running, the heading of the destroyer cannot be chosen and it is best to heave to to windward. The ship will fall off into the trough and should be allowed to drift so that her stern will pass within heaving line distance but clear of the disabled vessel. It is not difficult to accomplish this, by assisting with the engines, if the executive officer takes up a position on

the fantail or after deck house and keeps the commanding officer informed as to the distance between the two vessels as they approach.

In picking up the tow at sea, the destroyer should be allowed to drift until she is riding to a strain on the tow line. If the vessel is to be towed some distance and is not a naval vessel, it is a good precaution to lower a boat, weather permitting, and place on board the disabled ship a signalman and an officer so that the line can be tended to the satisfaction of the commanding officer. (See Chapter XXIX.)

The following description is given of the recent salvaging and towing to port of the three masted schooner *Geneva Kathleen* by a destroyer—the U. S. S. *Herbert* (Plate **164**, Fig.3).

"The *Kathleen*, loaded with lumber and drawing 16 feet aft, 15 feet forward, had grounded off Fort Pierce, Florida, about 18 hours before the arrival of the *Herbert*. A long swell had carried the schooner on to the bar until she showed 11 feet forward, 14 feet aft and at times pounded heavily. She was listed to starboard, her keel had been torn loose, she was making water slowly, and her rudder post was bent. The *Herbert* anchored 400 yards from the *Kathleen*, veered to 90 fathoms of chain, and the commanding officer had soundings taken about the schooner. These showed depths in feet as in the sketch, and as the bow had passed well up on the bar it was considered advisable to haul from her stern. A 3-inch messenger was passed by the motor sailer at 7.30 a.m. and the eight-inch hawser run and secured to a double 8-inch bridle passed from the king-posts and under the counter of the *Kathleen*. As the crew of the schooner seemed to be indolent and ignorant in seamanship, an officer, six seamen, and a signalman were placed on board her.

"The 8-inch manila was run through the stern chock and forward on the *Herbert* to the forecastle windlass and a strain was taken until the *Herbert's* stern was drawn across the tide and held in this position. An attempt proved that the schooner could not be hauled off; and as high water was not due until 3.30 p.m. it was decided to wait until early afternoon before making further effort. A half knot tide was running due to an eddy of the gulf stream, and this kept a good strain on the hawser, it being hoped that this strain would not only prevent the *Kathleen* from passing higher up on the bar but would per-

haps assist in working her stern off as the swells passed under her.

"The hawser was now passed twice around the base of the after gun mount (*Herbert* not being equipped with wire towing bridles) and secured to the bitts, plenty of chafing gear being used where the line passed through the stern chock; and at 1.30 p.m. both engines of the *Herbert* were started ahead at 5 knots. This was continued for over an hour and a half, occasional jolts of seven and a half knots being given in an effort to start the stranded ship. As the time of high water approached, both engines were, at 3.15 p.m., put ahead ten knots, and continued at that speed until 3.40 p.m. when the *Kathleen* began to slide off. At this moment the towing bridle parted at the schooner's stern and engines were immediately stopped; but a preventer bridle of the best line that could be found in the *Kathleen's* lazaret (an old 8-inch manila) had previously been rigged through the bowline of the towing hawser and as time was of greatest importance, a strain of 5 knots was placed on this. The schooner slid off at 3.45. The *Herbert's* anchor was picked up, the tow line was run out full length and shifted to the *Kathleen's* bow, and the *Herbert* towed the schooner to Miami, a distance of 130 miles. Turns were made for ten knots; but as the *Kathleen* yawed badly and could not be steered because of the condition of her rudder post, the engines frequently had to be slowed. No difficulty was experienced except when once during the night the schooner took a sharp yaw, parting the towline on the schooner's deck; but a light preventer that had been bent on forward of the break was payed out, a signal given, the *Herbert* stopped, and the line was quickly hove in and secured on board the *Kathleen*. At the destroyer end only a slight but not abnormal heating of the thrusts was noted.

"During the same week, the *Herbert* picked up and towed over 100 miles the steamer *Aragon* loaded with coal. The *Herbert's* towline was bent to *Aragon's* anchor cable, thirty fathoms of which was paid out to assist in weighting the line and to provide a steady strain. Turns were made for 10 to 11 knots; and although the *Aragon's* propeller was dragging, a speed of about 7 knots was made good against the gulf stream current."

HANDLING DESTROYERS AND OTHER SMALL CRAFT IN COMMUNICATING WITH LARGER VESSELS UNDERWAY.

Speaking Large Vessels. The greatest care should be taken in approaching large vessels which are underway. It is especially dangerous to attempt to take position full on the beam. The safe course is to come up on the quarter of the large ship and carry on communication with the quarterdeck or after bridge. This leaves the smaller vessel free to swing her stern towards the larger one if necessary for increasing distance, which could not be done if she were entirely overlapping the larger vessel and chanced to get a little too close. When a small vessel is running parallel to a larger one and rather close aboard, the smaller craft is dwarfed and her commanding officer loses power to realize the exact situation. He cannot correctly judge the steadiness of course of the big ship, changes in her speed, etc., and should she slow for any reason, he may be under her bow before he knows it. In repeated instances it has been proved that in such a position he is apt to close in without realizing it until he is so close that, if he puts his helm over, his stern will take against the ship's side and a smash will follow. This is but one example of the wisdom of the old destroyer rule: "*Keep your stern clear to swing, no matter what happens.*"

Another advantage of the quartering position is that in case of trouble, "full speed astern" will clear you in an instant.

During the war, escorting destroyers frequently had to deliver written secret instructions to vessels of convoys after they joined up at the entrance to the submarine zone, and it was necessary to do this with despatch in order not to slow the speed of the convoy or break up its formation. The destroyer first signalled the larger ship to steer a steady course and to maintain a constant speed (this is very important), then approached on her quarter to leeward and delivered a heaving line to the after main deck or to the rigged out life boat of the convoy ship. At the destroyer end of the heaving line was attached the written instructions in a sealed tin container, then a second heaving line. As the first heaving line was taken in by the larger ship, sufficient strain was kept on the second to keep the instructions clear of the water; and after the container was removed both lines were bent together and returned to the destroyer. Throughout this manœuvre, the destroyer main-

tained her position by slight changes of speed and light touches of rudder, always keeping her stern free to swing.

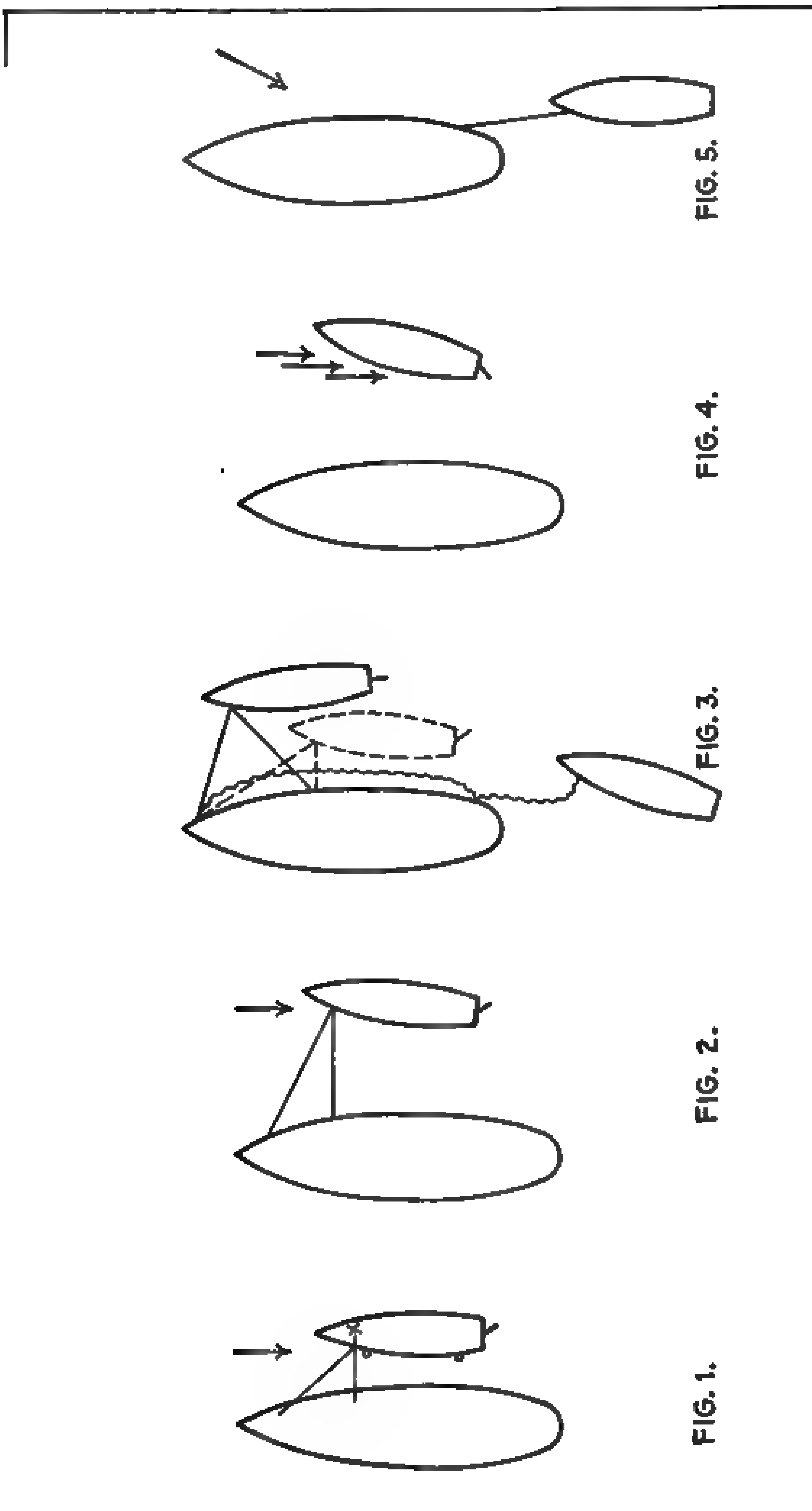
Taking Fuel, Stores, or Passengers from Another Vessel Underway.

What has been said in the preceding paragraphs about a small vessel communicating with a larger one applies to the case now to be considered, but with certain modifications. So far as destroyers are concerned, it must be recognized that the present-day destroyer is herself a fairly large ship. Furthermore, the present case is one in which *lines will be used;* and these, if properly handled in connection with the screws and rudder, introduce a new factor of very great importance. Moreover, the necessity for receiving stores or passengers makes a demand for closer approach than would be necessary for merely communicating.

Fig. 1, Plate **166**, shows a destroyer or other craft lying alongside a larger vessel *underway* and either steaming with her or being towed; preferably the latter. Here we must assume that the side of the larger ship is free from projections which can smash down upon the deck of the destroyer or puncture her side, and that any overhanging boats have been either swung inboard or otherwise gotten out of the way and that the same precautions have been taken on the destroyer. Also that good fenders are in use and properly placed. Note that the bow spring is taken from a chock well aft on the bow of the destroyer, giving an opportunity to pivot on the line. By a few degrees of right rudder, the destroyer keeps the water pressure slightly on her in-board bow. The bow-breast will hold her against the tendency to swing out, and may be assisted by easing the rudder; but this must be done very carefully, the helmsman standing by to meet her instantly to prevent crashing in against the side in case she is allowed to catch the water-pressure on the off-bow. With the lines as shown in the plate, the point x is a fixed point so long as the water-pressure is maintained on the inner bow; and the stern, protected by a good fender, may be swung in close to the side of the ship by a spoke of the wheel, and held there with the greatest delicacy of adjustment. If the sea is rough the larger ship should take it a little on the off-bow, but not enough to cause heavy rolling.

Note that the above is a case rather of "towing alongside"

Plate No. 166.



HANDLING DESTROYERS MANŒUVRING ALONGSIDE A VESSEL UNDERWAY.

than of "lying alongside" and that *the water resistance to the towing is the essential factor in the manœuvre,* making it possible to hold the small vessel as close or as far off as may be desirable by manipulation of the helm and the bow-breast. She may indeed be held off so far as to prevent all danger of contact (Plate **166**, Fig. 2). The method of approach to take up the position shown, will depend upon conditions existing at the time; but the following is suggested as practicable under average conditions (Figure 3). The larger ship being steady on a course which gives a lee without producing excessive rolling, the communicating vessel comes up under the lee quarter and takes the end of a stout hauling-line which has been led from well forward on the larger ship and passed aft outside of all. With this line slack she steams up onto the beam of the larger ship, at a safe distance, keeping well clear of the screws, and hauls across a five- or six-inch manila line from the bow of the other ship. This line is brought in through a chock fairly well aft on the destroyer's forecastle, forming a spring on which the destroyer drops in alongside by slowing or stopping, using the rudder as may be necessary for control. The bow breast is then gotten across and the destroyer held as already described. *To get clear,* the rudder is put a few degrees to right, and the bow-breast cast off. The stern swings in, bringing the pressure on the inner broadside, and the destroyer is swept bodily off (Fig. 4).

When conditions are such that towing alongside is not considered practicable, the simplest plan is to take a line and tow astern or a little under the lee quarter, using oil if necessary. (Fig. 5). This gives more independence of action and less danger of accident but is less convenient when passengers are to be transferred. Here the breeches-buoy may be found useful, or a small boat may be used in the oil slick.

The Maumee Method. The following method of fueling destroyers at sea was developed by the U. S. S. *Maumee* (fuel ship) and was employed with great success during the war and later during the trans-Atlantic sea-plane flight of 1919. By this method, oil was delivered through a four-inch hose at the rate of 25,000 gallons per hour, while the ships were steaming at speeds of four to thirteen knots, in a moderate sea, force of wind 3 to 4. It was estimated that vessels could be fueled in this manner during more than seventy-five per cent of all weather encountered (Plate **167**).

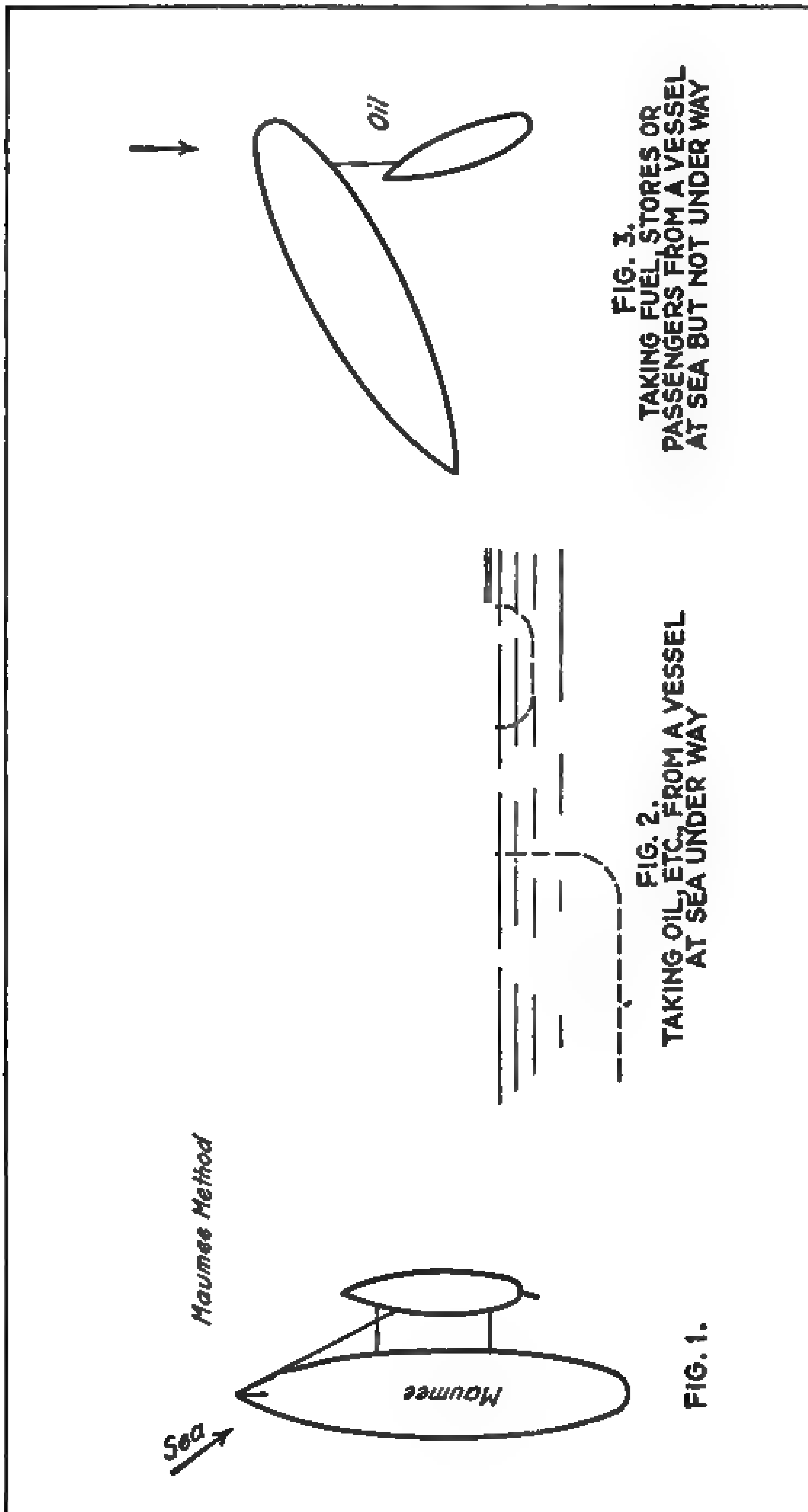
In this manœuvre rolling of the vessels will not interfere; but *yawing* is very dangerous, especially as the destroyer may be brought under the counter of the larger ship. The fuel ship therefore assumed such a course as to bring the sea forward of her off beam, preferably on the off bow. Her course and speed were signalled to the destroyer and both vessels were kept going ahead throughout the evolution. Various speeds were tried, but owing to the relatively high steerageway speed of the destroyer it was found that best results were obtained when the speeds of fuel ship and destroyer were regulated at about eight and seven knots respectively.

All gear was furnished by the fuel ship. A ten-inch manila spring was led from her bow chock and stopped along the rail, a 2-inch messenger being bent to this, fifty feet from the end, and *stopped along to the end*. The destroyer approached to leeward within about fifty feet of the *Maumee's* side and received the messenger by heaving line. This messenger was led through the after forecastle chock, taken to the capstan, and hove in, assisted by hand. Stops were cut as they came aboard and the ten-inch manila was given a turn around the base of the forward gun-mount and secured to bitts on the opposite side of the deck, a lashing on the bitts being necessary to prevent the hawser from jumping.

As soon as the destroyer signalled that the line was secured, the fuel ship hauled in the spring to take a strain and bring the smaller vessel to the relative position desired, and the destroyer regulated her speed at about one knot less than that of the *Maumee*. This spring, assisted by the force of the sea on the inboard bow, acted much as would a sea painter on a small boat, tending to keep the destroyer off; and with the 750 and 1,000 ton destroyers whose towing point was well aft on the forecastle, a slight *in* rudder was necessary to offset the effect of the sea on the bow. This sea-painter effect was not so pronounced in towing the modern type destroyer, whose bridge is farther forward.

A six-inch breast was now passed to bitts forward of the destroyer's forecastle gun and secured to bitts forward of the capstan. This line was subjected to considerable strain at times and when made fast was hove in on the fuel ship to reduce the distance between vessels to about forty feet.

An after breast of six-inch manila was passed in wake of the



FUELLING A DESTROYER AT SEA.

destroyer's after deck-house and secured but *tended.* This line was not absolutely necessary to the manœuvre but was employed as a safeguard against the delay that might be caused should a sudden lurch of the destroyer carry away the oil hose.

As soon as all lines were secured, the *Maumee* passed an oil hose to the destroyer by means of a wooden carrier suspended from a boom-head amidships (Plate 167). The hose was led to the destroyer's tank and pumping was begun when the ready signal was received.

Under unfavorable weather conditions, about forty minutes were required in passing lines and connecting up the hose; but in good weather the signal to begin pumping could be given within twenty minutes after the destroyer began going alongside. While fueling, the destroyer received stores and provisions by means of an after boom; and by proper regulation of speed and delicate use of rudder, no difficulty was encountered after the lines were secured, and no damage sustained by either vessel.

In very rough weather the destroyer was fueled while being towed astern, and oil was delivered to the older destroyers at the rate of fifteen thousand gallons per hour. With the newer type, however, considerable time is required in leading the hose while towing astern, as these vessels have no open tanks forward. The hose must either be coupled up to a deck fitting forward or led to an open tank abaft the after engine-room bulkhead.

Taking Fuel, Stores, or Passengers from a Vessel at Sea but not Underway.

Here the principal factor of the preceding case is lacking; viz., *the water-resistance* on the rudder and on the inner bow of the communicating vessel, by means of which it is possible to hold her off from the side or to swing her in, merely by a touch of the wheel; and to swing her clear when the time comes to cast off.

The present case, where the ship to be assisted is dead in the water, has many features in common with cases treated in later chapters on "Towing," and "Rescuing the Passengers from a Wreck." It has been explained in the chapter on "Handling Steamers in Heavy Weather" that a steamer lying dead in the water almost invariably falls off, bringing the wind and sea abaft

the beam and sometimes well on the quarter, the vessel drifting more or less rapidly to leeward. A destroyer or other small craft, taking a line from the quarter of a ship in this position, will usually tail down to leeward as shown in Fig. 3, Plate **167**. Here she should have a good lee, which may be improved by the use of oil, preferably from outlets fairly well aft on the small craft herself. There should be no difficulty in holding her bow close enough to the larger ship to admit of taking stores or of transferring passengers, either by a small boat working in the oil slick, or by the breeches buoy. Both vessels will drift and the destroyer will drift the more rapidly unless blanketed by the larger vessel. If the destroyer finds the other vessel drifting faster, she can hold her position to leeward by backing her screws. If any tendency is noted to swing in alongside the ship, the line should be let go and the small vessel backed off, as it would be dangerous to be jammed up against the lee side of the other vessel. This suggests that the smaller ship will do well to take the line through a chock fairly well aft on her forecastle, and on the bow which will cant her stern toward the stern of the other vessel, as indicated in the figure.

For getting a line across from one vessel to another, when a heaving line cannot be used, any of the methods described in the chapter on "Towing" may be used; that is to say, it may be carried across by a boat or floated down. A line throwing gun is very useful here (see Chapter XXIX). The shoulder-gun shown in Plate 185 is especially convenient for use on Destroyers, Submarines, Tugs and other small craft and should be supplied to all such.

A thrilling rescue was effected during the late war when the transport *Otranto* ran aground during a storm and rapidly began to break up. The British destroyer *Mounsey* arrived to her rescue and had no choice but to make her weather side. The destroyer commander signalled the transport to lower her life-boats empty to the water's edge and, using these as fenders, the *Mounsey* went alongside, took off over five hundred troops, and succeeded in backing clear. Those remaining on the transport perished.

The danger in lying alongside another vessel at sea is that due to rolling. Especially is this true in the later types of destroyers, because of the height of their bridges and midship gun platforms which plumb the ship's side about twenty-five

feet above the water's edge. Even in a light swell, considerable damage will be wrought to upperworks and the side will be dished by fenders.

It was found during the war that fuel oil is of doubtful value
ıe crests, it being too heavy; and for rescuing
r it should not be used, as it seems to stupify
ened from exposure. Storm oil as sold com-
light but is not furnished destroyers. One
ler tried out the commercial oil and reported
ctive, ten gallons being sufficient to ride out a

CHAPTER XXII.

THE SUBMARINE CHASERS.

Plate 168.

One of the earliest naval projects of large scope undertaken by the United States following the declaration of war in 1917 was the laying down of a fleet of armed motor launches, known as Submarine Chasers. Four hundred and fifty of this class, all of a single design, were built, of which fifty were purchased and operated by the French Government. From any point of view, whether that of the marine architect, the naval officer, or the seàman, these boats represented a novel type of craft; and the history of their operations is one of the most interesting records of seamanship in maritime annals.

The Chasers were originally conceived as "patrol boats." At the time the United States entered the World War the submarine menace had become the issue upon which the final outcome of the struggle appeared to balance. Anti-submarine tactics were essentially defensive in character, and depended upon the principle of establishing so close a surface patrol in selected areas that no submarine could expose itself without being subjected to immediate attack; or, at least, to having the information of its whereabouts immediately broadcasted by radio.

By the time the chasers were beginning to be delivered such progress had been made in the development of submarine detection apparatus and in weapons for attacking submerged submarines that a solution to the problem of direct offensive action against submarines appeared to be in sight. All chasers that operated in the war zone were equipped and specially trained as submarine-hunting units, and the original conception as to their mission and manner of employment became radically changed. Instead of patrol launches, operating merely as lookouts and with no offensive power except under conditions in which the initiative rested with the submarine, they became an agent for the detection, chase and destruction of submarines in a wide area. The matter of present interest is not, however, the

military effectiveness of the chaser, but the fact that these small vessels, conceived as launches, were called upon to fulfil the role of cruising ships. To the limit of their cruising radius they operated as seagoing vessels. All the problems of seamanship, of navigation, of interior organization and routine, to which the largest vessels are heir fell in their full weight to the lot of these ships in miniature. The weather was not tempered to their small size, nor was there any other class of vessel which showed a greater independence of it.

A study of the material characteristics of the chasers discloses many features of interest, but an understanding of the personnel factor is necessary to a proper appreciation of the performance of these vessels. Broadly speaking, the chasers were manned by naval reserves with little or no seafaring experience. A few experienced regular officers were assigned as commanders of large detachments and for the most important staff duties. There were also a number of experienced seamen in the persons of yachtsmen, warrant officers, and enlisted men of the regular navy holding temporary commissions, scattered throughout the force, but the mass of the 9,000 or 10,000 personnel involved, both commissioned and enlisted, were raw recruits—clerks, tradesmen, mechanics, professional men, college students, and men of leisure. Some of the boats leaving for the war zone faced a trip across the Atlantic in winter weather with not a man in the ship's company, from commanding officer to lowest enlisted rating, that had ever been off soundings. It would be not unworthy of remark had such a class of personnel succeeded only in maintaining operative seagoing vessels and in meeting the problems of existence through all the strange vicissitudes of a life at sea under conditions so severe. But this was only the beginning of their accomplishment. Their task included the operation of entirely novel and highly intricate apparatus in every department of ship activity, especially as regards the communication, ordnance, and main propelling equipment, and the conduct of a new system of tactical movements in which skilful efficiency represented the acme of professional naval seamanship.

Material Features. The hull design of the chasers is generally regarded as involving radical departures from accepted principles heretofore applied in any type of power driven craft, whereas it is in fact one of the oldest designs in existence. It has been

well described as that of a whaleboat with the stern cut off square at a point slightly forward of the overhang. The general appearance and arrangement of the boats are shown in Plate **168**.

Dimensions and Characteristics.

Length over all, 110 ft.
Breadth, extreme 14 ft. 8 in.
Designed draft, forward, 4 ft. 4 in.
Designed draft, aft, 5 ft. 10 in.
Designed displacement, 66.5 tons.
Actual displacement (loaded), 85 tons.
Speed, (loaded), 14.5 knots.
Propelling machinery, 660 h.p., triple screws; 3 "Standard" Marine Gas Engines of 220 h.p. each.

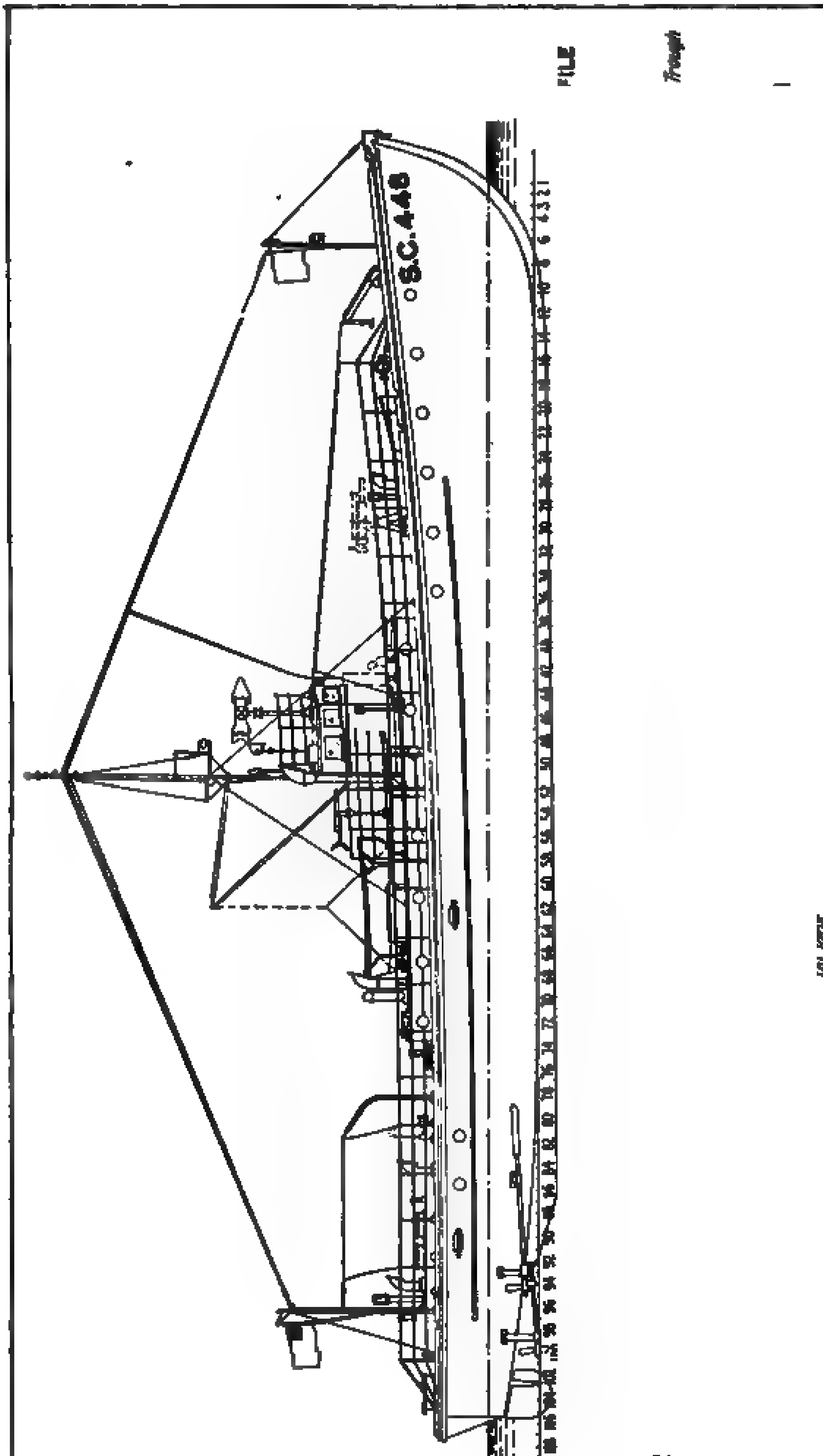
Propelling Machinery. The original design contemplated twin screws with one 300 h.p. engine for each shaft. In order to obtain the large number of engines necessary within the time allowable it was necessary to adopt a commercial stock model, and the "Standard," 220 h.p., six cylinder, air starting and reversing type was decided upon as the most acceptable. This forced the use of triple screws. Although this arrangement was originally regarded rather as a choice of undesirables it proved on the whole to be a very advantageous feature, considering the special nature of the service performed by these vessels. The outstanding qualities of readiness and reliability exhibited by the chasers were due in large measure to the third engine installation. With the inexperienced character of personnel in charge of these complicated mechanisms and the difficulty in obtaining spare parts, the matter of repair and overhaul became of more than ordinary importance. As the boats could carry out all their principal functions under any two engines the third engine gave opportunity for overhaul of one engine at a time without leaving station.

One of these vessels, while drifting, having lost her rudder, steamed to her base at full speed on various courses, using all engines, entered harbor, went alongside a wharf, cast off and went alongside a tender before a new rudder was obtained. The commanding officer reported that he "did not miss the rudder much."

Towing Gear.—The matter of towing arrangements was of peculiar importance in the chasers. The only practicable manner of transporting a large number of chasers across the

Atlantic was to have them cross on their own bottoms; and in view of their cruising radius of 800 miles, a considerable period of towing for the purpose of fueling alone and irrespective of breakdown, was a necessity. It was also the expectation that the chasers, operating in groups of three boats under peculiarly hazardous conditions, would have frequent occasion to take each other in tow. The first gear devised for the purpose appeared reasonably adequate, but it was found so seriously defective that it was abandoned and replaced by a new design which proved very efficient. This consisted of a strap-iron bridle, of 2-inch x 1/2-inch iron, passed entirely around the boat, but spiked securely to the upper guard rail and secured at the bow by heavy through bolts passing through both parts. The ends at the bow terminated in heavy forged eyes of sufficient strength to be practically an integral part of the stem. A wire pendant of about 8 feet in length with an eye splice in outboard end was attached to these eyes by means of a swivel pelican hook. The pendant was very convenient in making fast the tow rope; when casting off by means of the pelican hook it of course remained attached to the tow rope and the chaser was obliged to retrieve it from the towing vessel. On each quarter, projecting aft beyond the sharp knuckle formed by the square stern, a solid eye was worked into the strap iron bridle. When the chaser became the towing vessel the tow line was secured to the bight of a chain bridle which hooked to these eyes. The feature of passing the strap iron bridle entirely around the chaser was required in order to protect the vessel's longitudinal strength, as it was frequently necessary to tow several chasers in tandem. The only serious defect in this arrangement was the destructive action of the iron strap, spiked to the guard rail, on fenders and mooring lines and the sides of other chasers lying alongside.

Ventilation.—One of the severest trials to which the crews of these boats were subjected was the gasoline fumes which permeated all living spaces to the extent, in a few instances, of causing serious cases of asphyxiation. The question of ventilation in vessels of this type has a serious aspect aside from its relation to the health and comfort of the personnel. The most serious danger to which the chasers were exposed was fire, originating in the ignition of gasoline vapor, or liquid gasoline floating in the engine room bilges. More chasers have been lost from this cause than from all other causes combined. A thorough study



A SUBMARINE CHASER.

of this question, the results of which are published in Bureau of Engineering Circular Letter D-2, shows that proper ventilation is the most effective single preventive measure that can be applied. The causes which may produce a spark sufficient to ignite an explosive mixture of air and gasoline vapor are so numerous that the absolute prevention of sparks can hardly be deemed entirely practicable, and all precautions of this nature must be supplemented by thorough measures of ventilation to insure as far as possible that no explosive mixture is present.

In extinguishing one of the numerous fires that occurred in chaser engine rooms the experiment was tried of sealing the compartment against entrance of air and allowing the fire to burn itself out. The method proved surprisingly effective, the fire being smothered within a few minutes with no damage to machinery or electric apparatus and only slight scorching of paintwork. This method should not be entirely depended upon, however, on account of the uncertainty as to the air-tightness of bulkheads, hatches, and ports in individual cases, and the fact that to employ this method precludes the use of ordinary extinguishers which are effective if used promptly.

Handling Alongside a Dock. In the early stages of their training, the chaser personnel usually employed methods suitable for large vessels in bringing their craft alongside. With increasing skill they soon developed the practice of handling the ship almost entirely by the engines instead of by lines. With the large power available and the small size of the vessel the performance generally conveyed the impression of unusual snap and ease, though even the most competent officers frequently made the mistake of using too much speed.

Fueling at Sea. The experience of the chasers led to an independent development of a practice similar to that followed by the destroyer forces (Plates **166** and **167**). In weather which permitted towing with a short scope, the preferred method was to give the chaser a line from the stern of the tanker, the latter maintaining speed as permissible by the condition of the sea, and either floating the fuel hose down to the chaser to be picked up by a grapnel, or sending it in a runner down the tow line, the chaser hauling it in with a heaving line. Fueling *alongside* was often performed in moderately heavy weather. In this case it was found desirable that the tow line from the tanker should give as long a scope as practicable and should be taken

on board the chaser through a chock on the inner bow (Plate 166). A breast line from bow of chaser to tanker is secured to give the desired scope between vessels—from five to ten fathoms. The tanker maintains as much speed as conditions allow and the chaser, by use of her rudder, keeps the breast line well taut. A second breast line from stern of chaser to tanker is usually tended. The fuel hose should be slung from a davit on the tanker and paid out to the chaser as required in order to keep the hose clear of the water.

In this manner as many as six chasers at a time were fueled by a single tanker, two on each side and two astern. The whole operation from the taking of the tow line to casting off after receiving two thirds fuel supply usually occupied about twenty minutes.

Performance at Sea. The salient characteristic of the chasers was their remarkable seaworthiness. All of the boats operating under the United States flag in the war zone crossed the ocean on their own bottoms, and in a number of instances encountered winter storms of extreme severity. Several chasers built in Puget Sound made the trip to the Atlantic coast without escort or tender of any kind. The conditions with respect to sea and weather peculiar to the regions in which the greater number of the chasers operated were such as to test the seagoing ability of craft of this size to the utmost. Operating from 10 to 100 miles off shore in such areas as the north Atlantic coast of the United States, the English Channel, the Irish Sea, and off the southern and western coast of Ireland, they were often exposed to the full force of ocean gales, with the added disadvantage that in these regions of moderate depth the character of the waves during heavy weather is exactly of the type most difficult for small vessels to cope with,—short, high, and precipitous, with breaking crests and generally confused in direction owing to reflection from the land. In long, regular, deep-water waves, the chasers frequently passed through gales of extraordinary violence in such comparative comfort that the actual severity of the weather, as evident in large vessels, was generally underestimated. Under these conditions, the full force of the wind was apparent only when upon the crests of the waves.

The first chasers to cross the Atlantic were of those purchased by the French Government and manned by French crews. The personnel of these boats was excellent as regards

experience and ability in practical seamanship, but it did not include any trained navigators, and dependence for navigational direction lay in keeping touch with the escort vessel. Two of the chasers became separated from the escort, and one of them was never heard of again. The other, after a separation of about thirty days and great hardship from the exhaustion of fresh water and stores, made port under sail using a jury rig improvised from blankets. With the above possible exception no chaser was lost during the war through any cause connected with the seaworthiness of the vessel. This experience led to an idea that it would be necessary to send the boats across either on the decks of large freighters or with a single escort vessel for each chaser. Later, however, the United States chasers crossed in convoys of from twelve to thirty, generally with one escort vessel for four, five, or six boats. The number of escort vessels required was determined principally by the necessity for fueling the chasers at sea and with some regard also to the probability of machinery breakdowns in view of the inexperienced state of the personnel, rather than from any considerations of safety for the crews. On one occasion one of the escort vessels, a large ocean going tug, foundered during heavy weather; and in several other instances the safety of escort vessels was a matter of more concern than any situation that arose in connection with chasers.

Every type of vessels has its own individual peculiarities of performance in a seaway, but, generally speaking, all are equally subject to certain broad general laws of ship handling. All vessels if allowed to drift will assume a position more or less in the trough of the sea; all vessels may be strained by being forced directly into a head sea, and will either pound or bury their bows depending upon the speed used and the period, size, and conformation of the waves encountered; all vessels will run more comfortably with the sea abaft the beam on a proper combination of speed and course with respect to the character of the sea; and any vessel may be "pooped" through a disregard of these factors. The chasers were no exception in these respects, and yet the fact that they were successfully operated under all conditions by personnel who were in many cases inexperienced shows that their excellent design did give them a considerable immunity from conditions which, in the case of small vessels especially, often necessitate careful and experienced management. A few excerpts from reports of

experienced officers are added as showing the characteristic features of the design as evidenced by the performance of the vessels in a seaway.

"When drifting in a moderate sea she lay in the trough and rolled rapidly, but very seldom shipped water. In a rough sea she lay in the trough and rolled very heavily. At first the rolling motion of the vessel was alarming, but through experience we learned that the chaser was like a cork on troubled water, and we felt quite as safe drifting in the trough of a rough sea as in any other position, although this was the most uncomfortable one."

"I went through a 92-mile hurricane at various speeds, including full speed, by keeping the weather abaft the beam, and noticed no danger or damage to the vessel."

"These boats commence rolling in very moderate chop and under these conditions are distinctly uncomfortable. An increase in the size of the sea does not, however, increase the discomfort but may actually cause them to roll less violently. . . . Their motion is seldom violent and there is little tendency to throw objects around. . . . Very few of the chasers which had been at sea continuously during the war had racks for their tables. I cruised 8,000 miles in one from Lisbon to Archangel and there was seldom a time when we could not serve dinner on a table without racks. Of course things chased round a little, but nothing compared to a destroyer."

"Here the chasers were practically in the breakers and their performance in these breaking seas, of at least 30 feet height, was remarkable. It is the worst position I have ever been in in any type of boat, and I know of no other type which would have gone through so successfully."

CHAPTER XXIII.

SUBMARINES

§ I. PRELIMINARY.

While submarines are designed primarily for operating under water, it must be understood that even in time of war they spend many hours on the surface for every hour that they spend submerged. The motive power used on the surface is that of gas or oil engines; and fuel for these can be carried in quantities as great, proportionally, as the fuel carried by other surface craft. A modern submarine may have a cruising radius of from 6,000 to 8,000 miles. The motive power for running *submerged* is derived from storage batteries which give, at best, a speed from 12 to 14 knots and can furnish power for this or for much lower speeds for only a very limited period, after which the boat must rise to the surface to re-charge the batteries before another submerged run is possible.

There is reason to anticipate that ultimately a type of internal combustion engine will be developed which can be used under water as well as on the surface. Such a development will greatly increase the submerged capabilities of the submarine. But it must not be forgotten that there is a limit, *fixed by the human element involved*, to the time that may be spent submerged; —a limit which is a matter partly of physical endurance and partly of *morale*.

§ II. GENERAL FEATURES OF DESIGN AND CONSTRUCTION.

The cross-section of the submarine is circular except toward the bow and stern, where it takes the form of an ellipse, the major axis being vertical at the bow and horizontal at the stern. Except as modified by structure added to provide deck space, bridge, conning tower, gun-platforms, etc., the general shape is that of a torpedo (Plate 169).

In late designs the strength of the hull is such as to resist the crushing pressure of the water at a depth of 200 feet. In early types, the ballast tanks, which will be referred to later, were inside the hull proper. In later types they are built on, outside, making what is in effect a double hull and adding much to the normal strength of the structure, as well as to the protection from damage by collision or other accident. In this (double-

hull) type, the ballast tanks, in addition to being outside the real hull are below the level of the interior deck level. In the single-hull type also, they are below the interior deck.

Tanks habitually carried completely filled when the boat is submerged are called "Main Ballast Tanks" and are numbered serially from forward aft.

Tanks which are not habitually carried completely filled when the boat is submerged, or which are used for *weight compensation* are called "Variable Ballast Tanks." The variable tanks at bow and stern are the forward and after "*Trimming Tanks.*"

To the above are added other small variable tanks, "Auxiliary" and "Regulating," for various purposes. Each tank is provided with a *sea-valve*, a *vent-valve*, and connections for pumping and blowing by the use of air at 100-pounds pressure.

When it is desired to rid the tanks of water it may be done in three ways:

1. Blowing with air.
2. Pumping with main power pumps.
3. Pumping by hand.

Air flasks are provided, capable of being charged with compressed air to a pressure of 2500 pounds or over. This air can be blown into any tank at any desired pressure through air lines fitted with proper stop-valves. When air pressure is admitted into a tank (at its highest point) and the flooding valves (at the lowest point) are left open, the water in the tank will be blown out, provided the internal air pressure is greater than the external water pressure due to the "head" of water.

The main-power pumps are run either through suitable gearing or by clutches from the main shaft, and will pump against a great pressure. The water-lines are so arranged that all tanks can be opened up to the main pump.

The hand-pumps are operated entirely by hand, and would afford the final method used to free the tanks of water, when the air and electricity had failed. They can be connected to any tank.

The interior of the hull is divided into water-tight compartments, of which the most important are:

The Torpedo Room, at the extreme bow, where the torpedo tubes are installed and the "ready" torpedoes stowed. In large submarines, tubes are also installed astern.

The Battery Room, for the storage batteries.

Plate No. 169.

The Control Room, with all facilities for manœuvring, especially when submerged. Here is a sound-proof booth, with receivers for radio, submarine signals, and special listening devices as developed during the World War.

This is the station of the Commanding Officer when operating submerged.

The most important of the control-devices are the following:

Diving plane controls.
Steering wheel and electric controls.
Kingston-valves for flooding the ballast-tanks.
Trimming pumps and their manifolds.
High and low pressure manifolds.
Depth and tank pressure gauges.
Motor controls.
Periscopes and their hoisting controls.
Valves of ventilating system.
Inclinometer for determining Trim.

The Engine Room.

The Motor Room.

The Tiller Room.

The After Torpedo Room (if stern tubes are used).

Such space as is available in the compartments above enumerated is utilized as living spaces for the officers and crew. In the largest boats a separate living compartment is provided for the officers.

The modern submarine is a vessel of considerable size (500 to 2000 tons displacement), with good cruising radius, carrying its personnel in comfortable quarters (Plate 169) and affording fairly satisfactory space and facilities for exercise and diversion.

An elevated and roomy conning tower (Plate 170) gives ample opportunity for navigation and manœuvring on the surface, and the necessary instruments are duplicated in the control room below as above described.

Sanitation is provided by effective force pumps or air ejection systems which have been brought to a high degree of efficiency.

Cooking is done by electric stoves.

Steering may be by either magnetic or gyro compass.

Ventilation. The volume of air contained within the boats is usually sufficient to last from 5 to 6 hours before becoming vitiated. The renewal of air is provided for by a pump taking its suction from the bilges or lower portion of the boats, and dis-

charging outboard, while fresh air is admitted to the interior from the compressed air tanks until normal atmospheric pressure is obtained. The general practice is to start the renewal of air after being with closed hatches for 4 hours. After this time, 2 inches by barometer is removed every 4 hours, and air admitted from the air tanks to bring the pressure back to normal. The compressed air contained in the tanks is considered sufficient to sustain life for about three or four days in the ordinary type of submarine. Below is a formula for determining the number of days the contained compressed air in the air tanks of a submarine will sustain life:

X = Number of days life is sustained before symptoms of distress occur.
a = Air pressure in tanks, per square inch.
b = Cubical contents of tanks in cubic feet.
c = Number of men in crew.

$$X = \frac{11ab}{36000c}$$

NOTE.—This formula was computed assuming that one man uses .8 cubic feet of oxygen per hour; that there is 20 per cent by volume of oxygen in the air; and that symptoms of distress occur when the oxygen has been reduced to 12 per cent by volume.

§ III. OPERATING.

Insofar as submarines can be divided into types, the distinguishing characteristics are connected more with methods of submerging than with any other features, and even here the differences are fast disappearing.

All modern submarines have, under normal operating conditions, a small degree of *positive* buoyancy, as a result of which they tend to rise to the surface except when some force is being applied to keep them submerged. The forces which may be so applied are of two kinds,—*weight*, added by filling the ballast tanks which have been described, and *pressure*, applied by horizontal rudders or fin-like planes, called "hydroplanes," projecting from the hull and capable of being tilted up or down by mechanism controlled from inisde the boat. The hydroplane does not differ in principle from the horizontal rudder, and like the rudder it depends for its effect upon actual motion of the submarine through the water; the action being, in fact, one of *steering* the submarine either up or down. It will be seen that

Fig. 1. Conning Tower and Bridge of a Submarine.

Fig. 2. Periscope.

if there exists a small amount of positive buoyancy when all the tanks are filled, the submarine will, theoretically, rise to the surface when motion through the water ceases.

Another important factor which enters into the question of steering up or down, when the submarine (submerged) is actually making way through the water, is the *trim* of the boat.

There are three conditions under which submarines usually operate; viz., the "*light*" or cruising condition, the "*awash*" condition, and the "*submerged*" condition.

In the "light" or cruising condition, the main ballast, auxiliary ballast, adjusting, and midship tanks, should be kept free of water, and the water in the bilges should be kept as low as possible, in order to prevent the dangerous tendency to dive when there is free water in the main ballast or midship tanks, or in the bilges.

The forward and after trimming tanks are used to give the boat the most efficient trim for surface running. This trim is usually about 2° or 3° down by the stern, but it varies slightly with different types of boats. Except in cases where a main hatch trunk is fitted, the main hatch should always be kept closed when underway. The torpedo hatch is also closed and should never be opened when underway. The conning-tower hatch and all ventilators are kept open except in very rough weather, when every opening in the boat should be sealed except one ventilator which supplies air for the engines. This ventilator is so fitted that it can be lowered from inside the boat.

To run *awash* under the engines, a special type ventilator is provided, which can be closed from inside the boat. All preparations are made as before except that the "awash" ventilator is kept up. All tanks are filled except the auxiliary, which should be kept empty. The air for the engines is supplied through the ventilator, and a fuel-tank vent inside of the boat is kept open. The diving rudder is tended very carefully to prevent the boat diving, and a watch is kept on the ventilator, which can be closed instantly by a flat valve, should any water enter.

To Submerge. Control in the vertical plane is effected by the use of horizontal rudders or hydroplanes as already described. In the early boats, of the Holland type, one such plane aft, in the form of a horizontal rudder, was all that was required; but the increase of length in later boats has led to a demand for a pair of planes at the bow, and the Lake type has a pair amid-

ships also. The midship planes are always fitted to be rigged in, to clear the side of the boat when going alongside a dock or a tender. The bow planes are sometimes similarly fitted. The stern planes are identical in effect with the horizontal rudder formerly used alone.

When running submerged, the storage batteries are the only source of power. It is a peculiarity of the storage battery that the higher the rate of discharge, the smaller the total amount of power which can be taken from it, and vice-versa. This characteristic is utilized when submarines wish to make long submerged runs. The storage battery is divided, electrically, in halves. When these are connected in parallel, the voltage impressed on the motors is reduced, thereby reducing the rate of discharge. This connection will give the maximum total amount of power that can be taken from the battery. If the motors are now placed in series with each other, the power which would ordinarily be used to drive one propellor is divided between two and the boat is run at its lowest and most economical speed.

Diving and Running Submerged. There are two methods of submerging,—*the Stationary dive* and *the Running dive.* The stationary dive is made, as its name indicates, with no way on the boat. It is made, but only in shallow water, when the commanding officer is uncertain of the "trim" or the location of the center of gravity, as a result of recent changes in the variable weights in the boat:—stores, oil, torpedoes, etc. The object of this type of dive is to determine the location of the center of gravity, as this is very important in submarine handling.

When a stationary dive is to be made, an area on soundings, and, if possible, with a soft bottom, is chosen. When in the desired location, the boat is stopped and the main ballast tanks slowly flooded. When these are full, as indicated by water coming through the inboard vents, the *inclinometers* are examined to ascertain the condition of the fore and aft trim. In a submerged submarine, the fore and aft stability is much reduced. The first step after submerging is, therefore, to establish a fore and aft horizonal trim. It is assumed that the buoyancy is not completely destroyed when the main ballast tank is flooded, as the operation is rendered much more dangerous and difficult when the boat is so heavy as to sink before the fore and aft trim is obtained.

Assuming that the boat is submerged to a depth of eight or nine feet by the depth gauge when the main ballast tanks are flooded, the commanding officer looks to the angle of the boat in a fore and aft line. If, for instance, the bubble of the inclinometer is at the forward end of the glass he knows that the boat is lighter at the forward end than at the after, and he slowly admits water to the forward trimming tank, watching the bubble carefully and stopping in time to catch it at zero. During this operation care must be taken not to add enough water to destroy the buoyancy of the boat. If it is seen that to bring the boat on an even keel by flooding forward will require enough water to destroy this buoyancy, the plan is changed and water is pumped from aft forward, until the proper trim is reached.

When the fore and aft trim is obtained and the bubble is on zero, the total weight of the boat is examined and corrected by changing the amount of water in the auxiliary and regulating tanks. The best trim for slow speed (the most difficult condition for running submerged) is that of almost neutral buoyancy. If this condition is obtained, very little diving angle is needed to maintain the set depth. If the boat is heavy, i.e., has negative buoyancy, high speed and large rudder and plane angle are necessary to keep her from going below the desired depth; and if she is light, the same demands on power and rudders are made to keep her from breaking the surface. A very good trim is obtained when the boat will hang or balance on an even keel at twenty feet; this will leave something less than *one hundred pounds of positive buoyancy*, which amount is about right.

It must be emphasized that this type of dive should be made only in shallow water, as in great depths very real dangers are present. When a submarine is falling through the water there are only two ways of stopping the fall; one by blowing the water from the main ballast tanks, thus overcoming the downward momentum by the lifting force of buoyancy, the other to go ahead at full speed and raise her by the planing effect of the hydroplanes. As it takes some time and no little force to overcome the downward momentum of a large boat, dangerous depths and pressures may well be encountered before regaining control. The force necessary to catch a boat weighing 600 tons falling at the rate of a foot per second can be quickly figured but it will take longer to apply it.

On account of this danger and the time lost in making a stationary dive, charts and tables are usually made from which the amount and location of the salt water necessary to compensate for the fuel used and stores moved can easily be found, and the trim maintained during long runs and over protracted periods.

The running dive is the safest, quickest and most common method of submerging. In this method the trim must be approximately known, but large variations are permissible. After making all preparations, as described later, the main ballast tanks are flooded while still going ahead on the motors at normal speed with the halves of the battery in series, so as to have a large reserve of power if it is needed. When the ballast tanks are flooded, the speed may be reduced and the planes placed in the neutral position in order to ascertain the fore and aft trim and the total weight of the boat. As in the stationary dive, the fore and aft trim is corrected first and then the total weight. When the boat is so trimmed that the planes will hold the desired depth at slow speed with a small angle, it may be stopped with safety to make very fine adjustments; but in practice this is seldom done as the trim obtained at slow speed is good enough for all purposes. In this method of diving, the danger of the boat getting away on the flooding of the tanks is much reduced, as there is already sufficient way on to make use of the planes immediately and the downward momentum can be more readily overcome.

Preparation and Orders for Diving. When a submarine is on the surface there are several conditions existing that must be changed before it can submerge. Deck hatches may be open, awnings up, battery ventilation outlets open, and the *induction valve supplying air to the engines and living spaces is sure to be open.* These valves must be closed and all navigation gear and other portable objects on the bridge must be struck below. This work is a matter of routine but the commanding officer must make sure that all is done correctly. Below decks there are many things to be done. The valves mentioned above are all closed from inside the boat, beside which there are stop valves on the tanks to be opened, reserve air-banks to be connected to the air manifold, pumps to be tested and bilges pumped, and motor fields to be excited. With a well-trained crew the only order necessary is the signal to dive, given on the warning

howler or klaxon; but if the crew are inexperienced each order is given in detail and a report made on its execution.

A complete list of diving orders with their meanings is given below:

RIG FOR DIVING (described above).

VENTILATE INBOARD. This applies to the battery ventilation and on account of its importance is given as a separate order and requires a separate report when complied with.

SHIFT THE CONTROL, to conning tower or control room. Before diving, the rudder and engine telegraphs are operated from the bridge.

STATIONS FOR TRIMMING DOWN. At this order the junior officers and crew take their diving stations and await orders to open valves and vents.

SECURE THE ENGINES. At this order the engines are stopped, the motors made ready, and all outboard openings in the engine room closed. When the commanding officer takes his diving station, usually at a periscope from which a view of the depth gauge is had, he orders: —

REPORT. At this the man in charge of each station reports through the voice tube or telephone that the valves and machinery at his station are, in all respects, ready for diving. These reports may be made to the executive officer but in any case they should be checked by the executive or commanding officer.

CLOSE THE CONNING TOWER.

AHEAD BOTH MOTORS. If this has not been given before or unless a stationary dive is to be made.

A further word of explanation is here necessary. An order to BLOW a tank is an order to CLOSE the vent and an order to FLOOD a tank is an order to OPEN the vent. An order to flood or blow requires two reports of execution, one that the water valve is either opened or closed, as the case may be, and another that the vent is in the correct position. Now comes:

FLOOD MAIN BALLAST. This is acknowledged by the reports that the kingstons and vents are open. When the man at the air manifold reports that there is water at the manifold, the commanding officer, after waiting long enough to be sure that there are no bubbles left in the tank, orders:

CLOSE THE MAIN VENTS. This leaves the kingston valves still open and the tanks are ready for quick blowing. Orders are now given to regulate the trim such as:

FLOOD—lbs. in after trim. In flooding, pumping, or blowing small tanks, a definite amount is always designated and a report is made when the gauge passes an even mark, such as "1800, 1900, in after trim" and the final amount is reported when the tank is secured.

When an order is given to *blow* a partially filled tank, the man at the station on the outboard valve must never open it until a report is received that *the pressure in the tank is greater than the sea pressure.* To do so will allow water to enter the tank, which is the converse of what is desired; and if the tank is a large one, only slightly filled, great danger exists that enough water to sink the boat may enter. When taking water from a partially filled tank, it is much safer, quicker, and more economical, to use the pumps. Boats have been known to hit the bottom at dangerous depths by trying to blow. It is one of the most dangerous mistakes that can be made; as will be clear from the following illustration:

A submarine is running at sixty feet, with five thousand pounds of water in the auxiliary tank, which is designed to hold twenty thousand. At sixty feet there is a pressure of thirty pounds per square inch on the outside of the tank. Now if the kingston is opened before the pressure is built up in the tank, the water will enter with a head of thirty pounds at a rate governed by the size of the kingston, usually about six inches in diameter. With this opening it will take only a few seconds for ten or fifteen thousand pounds of water to enter the boat. As this is giving the boat negative buoyancy, she will immediately gather momentum toward the bottom.

To catch her this water must be got rid of and the momentum overcome. Things happen quickly in submarines and one can not be too careful. THE BEST RULE IS TO PUMP, NOT BLOW, A PARTIALLY FILLED TANK.

When the boat is in the proper trim, the order is given to RUN AT—FEET. It may be sixty or only sixteen, but the depth is always specifically designated.

To bring a submarine to the surface it is only necessary to get rid of the water in the main ballast tanks. Any tank may be

freed of water in either of two ways; by pumping with high or low pressure pumps or by blowing with compressed air. The usual method is to blow until a good percentage of positive buoyancy is obtained and then pump the tanks dry. This is a quick method and is economical of compressed air. Hence, after making sure that the vents are secured, the order is given BLOW MAIN BALLAST. The pumps are started when positive buoyancy is assured.

§ IV. HANDLING SUBMERGED.

Whether or not the boat handles well submerged depends almost entirely on the trim. Heavy seas will make a difference in handling, particularly near the surface, but the one big factor over which the commanding officer has control is the *trim*, which should be very carefully regulated. A poor trim can be overcome by high speed but it is unseamanlike and only the gravest emergencies should be allowed to interfere with having a perfect trim.

The effect of speed on handling submerged is tabulated below:

HIGH SPEED:

1. Requires small plane angle.
2. Requires small angle on boat to change depth.
3. Can be out of buoyancy trim as much as 4,000 or 5,000 pounds.
4. Can be out of fore and aft trim.
5. Planes are difficult to operate and boat changes depth and angle very quickly.

LOW SPEED:

1. Requires large plane angle.
2. Requires large angle on boat.
3. Must be trimmed more accurately as to buoyancy.
4. Must be trimmed more accurately fore and aft.
5. Planes easy to operate, boat easy to control, changes depth and angle slowly.

Periscopes. A periscope (Plate **170**) is an instrument for conveying to the eye of an observer inside the submerged submarine an image of objects on and above the surface of the water as the observer would see them directly if his eye were at the height occupied by the upper end of the periscope. It

consists of a long tube projecting upward through the deck of the submarine so that its upper end will be several feet above the surface of the water when the submarine is submerged to a depth sufficient for concealment. An opening in the upper end carries a prism so placed that rays of light striking the prism are reflected downward through the tube where they strike upon the object glass of what is, in effect, a telescope. The light rays from the lens are again reflected by a prism to a horizontal eye-piece at the lower end of the tube, inside the control-room of the submarine, and thence to the eye of the observer, who thus sees what he would see if he were using a telescope, with his eye at the point occupied by the upper prism of the periscope.

Some periscopes are fitted for scanning the sky and are called altiscopes. One of this type is usually provided in each boat. The latest periscopes are bi-focal; that is, they have two powers of magnification in addition to unity; usually, 1, 5 and 6. The lower power with a large field is used when the object viewed is near or when a search is being made for an object. As the field of the high power is very much smaller than that of the low power, it is easier to *pick up* an object in the latter, after which it can be examined through the high-power eye-piece. When nearing another vessel while submerged, the low power eye-glass should always be used as the other is apt to give an incorrect idea of distance. Telemeter scales are placed in the fields of all periscopes to aid in estimating distance and after considerable practice they are very helpful; but the rule to shift to low power when close aboard should never be disregarded. Periscopes are provided with azimuth circles so that bearings may be taken, and all torpedo firing is done from this instrument; therefore great care should be taken to keep it properly bore sighted;—that is, to have the cross wires split the center line of the target when the scale reads zero. They are fairly strong instruments but the same care used with all other optical instruments should be observed in their use.

On the surface a submarine will carry its way as far as any other vessel of the same tonnage; but submerged the way is lost very quickly. This should be remembered as it may be of value when the boat is brought to the surface near unexpected traffic. Another point that should be kept in mind is that backing the screws submerged tends to drag the stern down. This is of value when the boat is heavy forward and going down

rapidly; in this case backing will not only kill the way but will help level the boat when the planes are inadequate.

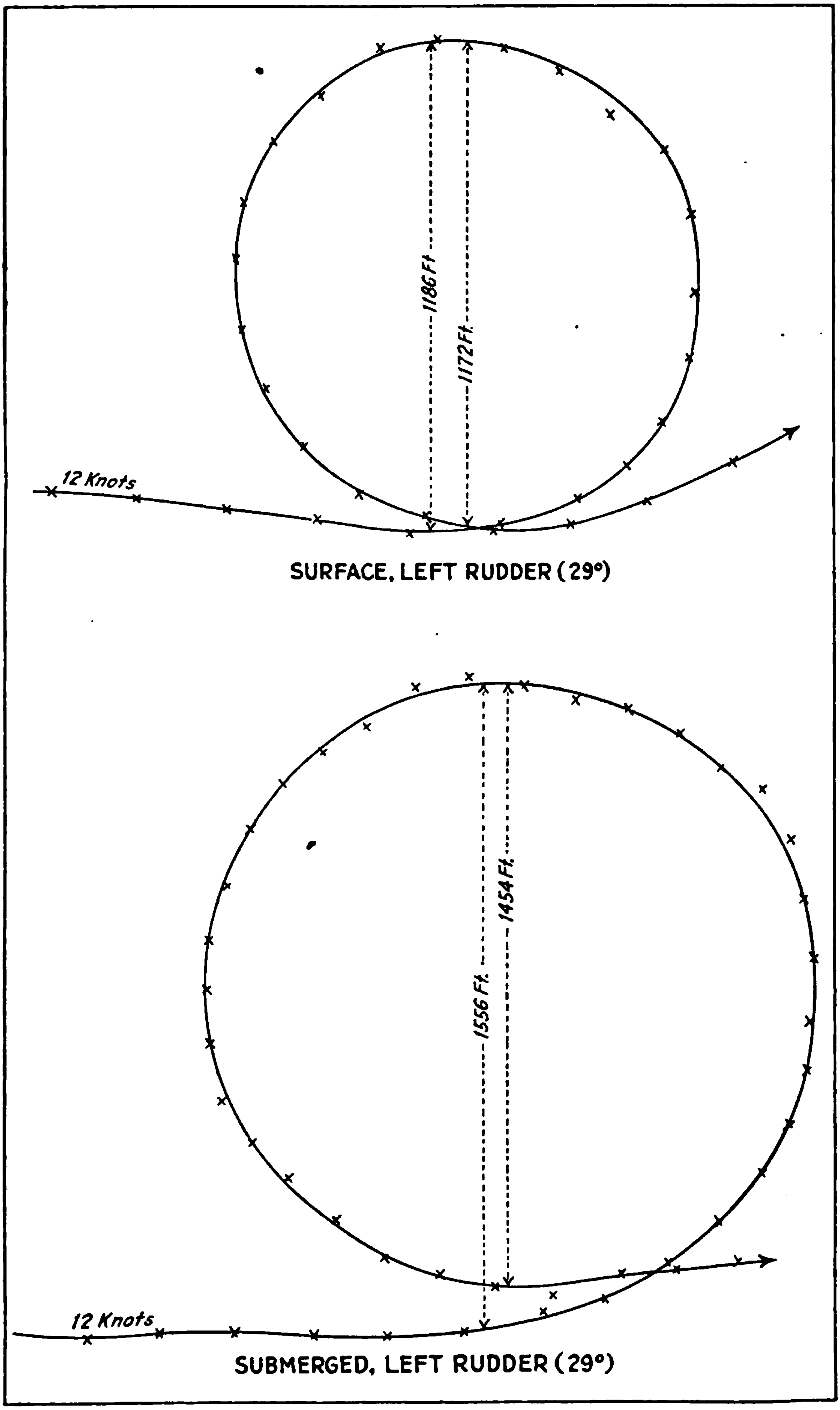
When submerged the turning circle is increased (Plate 171). The same principles about backing the inboard screw when turning apply as in surface work. In turning with hard over rudder, a heel is given the boat, the degree depending on the speed. As this throws the rudder out of the vertical plane, it takes on a little of the character of the hydroplanes and makes depth-keeping more difficult. This is a point to be watched when firing torpedoes, or when, for any reason, accuracy of depth is essential. When holding a course, no more than five degrees of rudder angle should be used.

When running submerged at high speeds, the bow planes are usually set at an angle determined by the trim, which will allow a minimum use of the stern planes, by which changes of depth are controlled. At low speeds, the reverse is true. The stern planes are set and the bow planes used like the wings of an aeroplane, raising or lowering the boat by their hydroplane effect without changing the inclination of the boat. If the stern planes are used for this purpose it must be remembered to use them in the opposite direction from that used in changing the inclination of the boat. To give the boat an angle down by the bow, the stern planes are put down, throwing the stern up and the bow down. If the "planing" effect is wanted, a smaller angle is used; and on account of the low speed, the water, acting on the under surfaces of the planes, will tend to raise the boat as a whole rather than to change the inclination. When running at fairly high speeds, the bow planes are set and the man at the stern planes "follows the bubble" on the inclinometer. As the planes are connected to their controls in such a way as to give *down* angles when the wheel is moved *forward*, this will give *down* plane when the bubble moves forward, overcoming the tendency of the bow to rise.

§ V. DO'S AND DONT'S.

Do not attempt to pass under traffic or tow lines. It is much safer to wait and go astern.

Do not submerge unless all bilges are reported dry. A free water surface is a dangerous thing in a submarine, because of the tendency of the water to rush forward or aft, changing the trim suddenly and violently.



TURNING CIRCLES OF A SUBMARINE.

If, after coming to the surface, the boat is heavy at one end, examine the valves to the trimming tank at that end. One may have been left open or a sea valve to the bilges may be cracked. Free water may give the boat a sudden and dangerous lurch at a moment when it is least expected or desired.

If submerged, do not flood an empty torpedo tube by opening the outer door. This is a sure way of hitting the bottom. Always pump the tubes full from the forward trimming tank. This will not change the trim or add weight to the boat.

Do not run at excessive angles. Oil will run out of the motor bearings. Excessive depths or the bottom will soon be reached, especially in long boats.

If chlorine is smelled come to the surface at once, but do not blow a tank surrounding a battery or one which could leak into it. Blow everything else. Get the load off the battery as soon as possible. Pump tanks surrounding a battery.

If the boat is fitted with a duct keel, always fill it before the final trim is obtained. A leak into this passage may throw the boat out of trim just as a torpedo is fired.

Do not wait for the muffler valves to leak. Examine them periodically.

Watch the bilges. Allow no free water.

Watch the exhaust valve drains.

Watch the pressure on all tanks. Note that a leaky tube drain may give excessive pressure on forward trim when firing torpedoes. Crack and close the main vents occasionally.

When coming up, pass from fifty feet to periscope depth as quickly as possible without excessive angles.

Collision submerged has long been considered fatal: it has been done without losing life. But do not try it.

Hitting the bottom too hard may ruin the battery.

Going ahead to "catch her" without blowing is bad practice.

You may blow two blasts on the whistle submerged but only one spout will show and a misunderstanding may occur. It is better to expose the bridge and indicate your intentions clearly in plenty of time to avoid collision. Always be ready to blow.

Look out for main ballast blows freezing in cold weather, due to water in the lines and expansion of air.

Check gyro-compass with magnetic frequently, particularly when the boat is rolling or pitching.

Watch battery grounds. Remember that with grounds on both legs, the weaker will go and a fire may result.

The man on the listening device should report all noises, however slight.

Do not make a stationary dive off soundings.

Do not blow a partially filled tank.

If a kingston leaks, put about five pounds pressure in the tank when on the surface.

§ VI. EMERGENCIES.

Battery fires are caused by short circuits. The trouble may be in an acid-soaked power lead, a broken battery jar, acid spilled in rough weather, or any one of a great many things; but the first treatment is always the same. *Get the power off the battery.* This removes the cause and the fire now becomes an ordinary one and will succomb to ordinary treatment. If the fire is of no great extent when discovered, a fire extinguisher will probably be all that is necessary. A large fire may require the compartment to be battened down. If this is the case be sure that all the voice tubes and ventilation ducts are closed. A bad fire in the engine room will always go out if the engine is started and the air supply to the engine room cut off.

The treatment for battery explosions is entirely preventive. After the explosion the wounded will require attention and there will be a fire to fight, but the explosion is over and there will probably not be another. Proper ventilation is the best preventive. If the explosive gas is present, a motor is sure to spark and supply the necessary heat to explode it. Do not be parsimonious of the water in the battery. Use the blowers at full speed when near the end of a battery charge. Four per cent of hydrogen is enough to cause an explosion. The blowers are large enough to carry it all away if the ventilation system is tight. There will be no warning, so watch the ventilation.

Chlorine is caused by the passage of an electric current through an electrolyte containing salt in solution. The emergency treatment here is the same as that for a battery fire. Get the current off the battery. If submerged, come to the surface but do not put pressure on a battery tank unless the salt water was actually seen to enter the battery through some other means than the battery tank. Blow the tank not adjacent to the battery giving off the chlorine, and pump those near it. As chlorine gas is poisonous, plenty of fresh air is necessary to clear the gas from the boat. If only a small amount of water has entered the

battery, the chlorine may be got rid of by charging the battery at a high rate. This will produce a large amount of gas for a time but after a couple of hours all the salt will have been acted upon and no more chlorine will be generated. This treatment is harmful to the battery and should not be used unless imperative. If large amounts of salt have entered the battery, the plates will have to be taken out and washed and all electrolyte renewed.

To have salt water in the lubricating oil is always a serious matter. The results of this are the wiping of bearings, burning of piston heads and cracking of cylinders. Water may enter lubricating oil through a variety of paths; leaky muffler valves on a deep dive, a leak in the oil cooler, a cracked cylinder, and leaky rivets in the stowage tanks, are common causes. Salting of the oil may always be determined before the condition becomes dangerous, by the use of silver nitrate solution. The oil should be tested by the addition of a few drops of the silver nitrate to a sample of oil at least once every hour that the engines are running and *always before starting an engine.* Once the salt gets a start there is a lot of work ahead of the officers and crew before the engines can be run again.

Finding oneself in dangerous depths is about the only other emergency that is peculiar to submarines. This condition is, almost without exception, due to having the boat negatively buoyant. The seriousness of the situation depends on the depth of water and the condition of the hull. If a large compartment is flooded and the water is much over two hundred feet deep, there is not much that can be done from within the boat. If the boat is stuck in the mud at one hundred and fifty feet and the hull is still tight there is every reason to believe that she may be raised by the crew. Submarines of our Navy are built and tested to withstand two hundred feet of water. This means a pressure of ninety pounds per square inch, and the pumps and air lines are designed to work against that pressure. If stuck in the mud in deep water, the first thing to do is to get as much positive buoyancy as possible. This may be done by blowing or pumping tanks, provided the pressure is not too great; even if it is, the effort must be made. Remember the principle of blowing full tanks instead of partially filled ones, for in an emergency of this sort one can't afford to waste a single pound of air. Watch the pumps, when working at great depths; for the

glands and stuffing boxes are sure to leak and may blow out. Always be sure that the pump is running before opening the outboard valve, otherwise some additional water will have to be pumped out, as the pressure will back it in through the pump. The chances are that a submarine will get stuck in the mud at the *bow*, as this is pointing down when the dive commences. This leaves the screws clear for use and makes the salvage that much easier. The first thing to do is to free the heavy end or the end that is being held by the mud. Blow the forward tanks first, so that the buoyancy thus gained will work toward putting the boat on an even keel. If this does not free the bow, the screws may be backed. Backing the screws has a threefold value when in this condition. As was mentioned before, backing the screws when submerged has a tendency to drag the stern down, thus forming a lever to break the bow out of the mud; it also gives a powerful pull away from the mud, and, if continued for some time, may wash the mud away from the bow in sufficient quantities to aid in freeing the boat. Backing on one screw and going ahead on the other gives a strong turning moment that is of no little value; if the directions of the screws are reversed from time to time an effect of sallying may be produced. The moving of heavy weights will also have a value, particularly if the boat is held by only a small portion of the bow. If the torpedo tubes are empty and can be opened, blowing water slugs from them might help in breaking the bow clear. The above are a few applications of the principles involved; circumstances will have to govern the choice of methods.

§ VII. HANDLING ALONGSIDE.

The main points to be remembered in handling a submarine alongside a dock or tender are that the bow and stern are delicate and that the boat will invariably back into the wind. The bow casting is very strong, but only a foot or so abaft this are the torpedo shutters, which will not stand any sharp blow or any considerable pressure without bending or breaking, either of which will put the torpedo tubes out of commission. The skegs on most of the older boats and on many of the newer ones project far out from the hull. As these skegs support the rudder and the stern planes and only partially guard the screws, a small blow may put the whole after end of the boat out of commission. Except for these peculiarities, submarines are very

easy to handle. There is a large reserve of power for both backing and going ahead which can be almost instantly applied. On account of the tendency to back into the wind, care must be taken in getting out lines, to be sure that the stern is under control of one line as soon as possible. Do not hesitate to use power. Full power can be used for a short time without getting much way on the boat and may be just what is needed to overcome a bad tide or a strong wind. Do not confuse power and speed, however.

When manœuvring, do not neglect the rudder. When turning in a confined area, the rudder will assist the screws to a great extent. The rudder must be used with regard to the direction of motion, however, and not to the screw direction. Do not shift the rudder until the way is entirely killed, when backing and filling. The screws have a powerful turning force and can turn a submarine around in a length and a half if there is no wind.

The use of lines in securing and coming alongside with a submarine is the same as with a surface craft. Always cross the lines so that they may be used to warp in, whether going ahead or astern.

§ VIII. HEAVY WEATHER.

Submarines, properly handled, will live through any storm. The only requirements are that the hatches be secured in plenty of time to prevent water entering the boat and that there is plenty of sea room. A submarine can be handled from within almost as well as from the bridge, except of course in narrow waters; so on the approach of a storm do not run the risk of losing a man by trying to keep the bridge control too long. Do not pound into a heavy sea. To do so will strain the hull and will surely bend or break the torpedo shutters. A submarine, like any other propellor driven ship, will naturally ride most easily with her stern to wind and sea. If forced to lie-to, do so in this position. It may be possible to keep a man on the bridge when lying to, while it would be foolhardy to try if heading into it. If it is of advantage to run before the sea, it can be done more easily by regulating the speed to the length of the waves. This will have to be done by running on the motors, as the engines will not go slowly enough. If the speed is too great, waves will come over. Oil may be used to advantage as with surface vessels; a good way to apply it is to pump it out with the bilge pumps. If the bilges are dry it will do no harm

to pump a little water in, and then, after adding a little oil, to pump them dry again.

No difficulty should be experienced in submerging in a seaway if the sea is brought abeam or abaft the beam.

§ IX. TOWING.

Submarines are fitted with a towing pendant consisting of from fifteen to twenty fathoms of six or seven inch wire. This is fitted with a pelican hook for making fast to the towing shackle in the bow. The pendant is usually carried stopped down on deck, pelican hook attached, and a tripping line run from the hook to the bridge.

As the motors are the most reliable part of the motive machinery of a submarine they are usually in commission when the boat has to be towed. This makes the operation of picking up the tow much easier than is the case with larger vessels. Of course if the submarine has not the use of her motors the problem of picking up the tow is the same as for any other type of ship.

If a large ship is picking up the tow it is easier for the submarine to manœuvre for the tow line than for the larger vessel to do so. If the towing vessel will lie-to with the wind on the quarter or bow, the submarine can come up under the lee quarter and, in smooth weather, take the tow line itself, thus eliminating the use of messengers and other small lines that would encumber the deck. If the weather is too bad for this, it may be possible for the submarine to handle a messenger and a heavy tow line, but it is improbable, for the decks are small, and, in bad weather, very wet.

After the tow line is made fast, the submarine may be of great assistance to the towing vessel in getting under way. By using her motors, the strain of starting may be greatly relieved and the danger of parting the line reduced. The same principles apply in towing a submarine, as to speed and length of tow line, as with other surface craft. As our submarines range from three hundred to two thousand tons displacement, it is impossible to designate the size of the tow line; it should be remembered, however, that a submarine has more drag than a surface craft of the same tonnage on account of the greater percentage of below-water body.

If a submarine is to take another in tow, it should be done about as follows. As only the very latest types have bitts aft,

a line should be passed around the conning tower, using plenty of chafing gear, and the ends taken aft to a point about one third the distance from the conning-tower to the tail, before shackling the ends together and making the tow-line fast to this improvised bridle. This will allow the stern to swing, and make steering easier. Stop the bridle firmly to the cleats abreast the conning tower to prevent rendering.

The tow line should be coiled down near the stern, with a good man stationed near to prevent its slipping over the side and fouling the screws. With the tow line led well forward, outboard of everything, on the weather side, pass on the lee side of the other boat as close as the weather will allow and send a heaving line aboard. If the weather is such that it is impracticable to come within heaving line distance, make a heavy float fast to the tow line, and, after coming as close as possible, drop it where it can be picked up. When the heaving line is passed or the tow line is in the water, stop dead. The two boats will drift at the same speed and if the tow line is paid out at sufficient speed to prevent its dragging, the other boat will have no difficulty in pulling the end aboard or picking it up. This method has the disadvantage that the tow is over the weather quarter of the towing boat and she will have to manœuvre to place it on the other side with consequent danger of fouling the propellors, but it is the best method available if the boat to be towed is completely disabled. If the boat to be towed has the use of her motors the tow line may be passed as outlined with the larger vessel. The towed boat can come up on the lee side of the towing boat and take the heaving line, or she can manœuvre to pick up the buoyed tow line if the weather is heavy.

CHAPTER XXIV.

KEEPING STATIONS AND MANŒUVRING IN SQUADRON.[1]

§ I.

It is proposed here to discuss in rather general terms some of the difficulties connected with work in squadron from the point of view of seamanship—not at all from that of tactics. We may regard tactics as prescribing, in a very definite way, certain things which must be done; while seamanship deals, in a much less definite way, with the manner of doing them. The two subjects necessarily overlap each other throughout a considerable field and within this field it is impossible to discuss one of them without touching upon the other. This is the excuse for such comment as is here included upon tactical formations and manœuvers.

All work of ships in squadron is designed as a preparation for battle, but it may be questioned whether sufficient consideration is always given to the difficulties which, in time of battle, will be added to those which are connected with station-keeping and manœuvring at other times. The smoke from the guns and the funnels of ships ahead—all of these ships being under forced draft—will obscure the view from the conning tower in all directions, but especially ahead. The ship next ahead will be seen only a part of the time; the leader of the column probably not at all. And the use of instruments for keeping position will be altogether impracticable.

In ordinary cruising and manœuvring the conditions are much better; the next ahead can be seen at all times, the leader occasionally; and sextants, stadimeters and range-finders are always available for measuring distances. It is questionable, however, to what extent advantage should be taken of these conditions. Certainly a constant effort should be made to train the eye in judging distance both by day and by night—the last without the aid of lights. And it would seem desirable to recognize the fact that only under very exceptional circumstances, such as will rarely exist in battle, can a column of vessels keep their distances from the leader.

[1] See *Notes B,* "Handling Ships," at end of this chapter.

Whatever method is used for estimating distance, it will usually be found easier to keep position than to regain it after it has been lost. The moment a tendency is recognized to close up or drop back, the speed should be changed enough, and only enough, to check the tendency. This is better than to wait until the error is so great as to call for a more radical change, which, if prolonged even a very little more than necessary, throws the position out in the other direction.

A caution is called for here. It has already been remarked that a column of ships cannot keep distance from the leader. It seems probable that, in battle, each ship will be reduced to the necessity of keeping distance from the next ahead; and that there will often be a good deal of uncertainty even about this. There will be many times, however, when it is practicable to judge whether the next ahead is or is not approximately in position with reference to her own next ahead. Thus by watching as many ships ahead as can be seen, whether one or two or more, it will often be possible to discriminate between a real and an apparent fault in position and to avoid the vexation of closing up on the next ahead only to find her a moment later dropping back because she has herself been ahead of position.

In spite of all that can be done, a ship will at times get quite badly out of distance. It may be that her revolutions are not quite true to standard, or that she has been badly steered, or that the vessels ahead have changed their speed. When distance has been lost from this last cause, caution must be used in closing, as the other ships may at any time resume standard speed.

Here it may be remarked that *more than half the troubles in station-keeping come from irregularity in the speed and steering of the guide,* and that no amount of trouble should be thought too great to keep these uniform. Good steering can be insured by careful training of the helmsmen, and the electric revolution-telegraph which is now installed in battleships gives the officer of the deck information at all times of the number of revolutions actually being made. The officer-of-the-deck sets on this telegraph, by means of three dials, the number of revolutions he desires to make. This is indicated in the engine room and repeated back over the instrument so that a duplicate set of dials on the bridge record the number of turns that the engine room understands it is to make. The officer-of-the-deck can always tell how many revo-

lutions he has ordered by looking at his instrument, which also shows that the engine room understands correctly.

While a perfectly uniform speed is more important on the part of the guide than on that of other ships, it is of immense importance to every vessel of the fleet, both for her own comfort and for that of all the vessels associated with her. It is rather surprising how little attention is usually given to acquiring this habit. As a rule, if ships keep their positions reasonably well, very little thought is given to the methods by which they accomplish this result, and a ship which is incessantly ranging up and dropping back *a little*—without getting seriously out of position—suffers nothing by comparison with one which steams steadily hour after hour. Yet the difference between the two is very great, especially in the consumption of coal and in the demand upon the fire-room and engine-room force. It is worth while to give great attention to this point and to *require* the closest possible approach to perfect steadiness on the part of the officer of the deck and the engineer's force. An excellent way to develop this is by steaming in line. Here errors in *speed* manifest themselves at once and yet they inconvenience no one but the offender. But for good results here, as in other cases, the steadiness of the guide must be beyond suspicion.

Under conditions as they exist at present, some variation in speed must be anticipated, and it is very important for every ship of the column to have timely notice of a change made by the ships ahead. The speed-cones as at present used give information of changes in units of one knot. The rules for their use could easily be modified to admit of showing smaller changes. But any system of signalling by shapes hoisted at a yard-arm is crude and unreliable and in battle would probably break down altogether. It would not be difficult to devise an electrically controlled system for showing in a sheltered position at the stern the number of revolutions which the ship is making, or, perhaps more simply, the deviation on one side or the other from the number which is for the moment prescribed, whether this be "standard," "half" or "slow." Whatever system is used, the signal for a change should, when practicable, be shown coincidently with the change.

Attention has been called to the importance of judging distance without the use of instruments. The clearness with which de-

tails can be seen on the ships ahead is a great help here. At certain distances, for example, the name on the stern of the other ship can just be read. It will almost always be possible to select two objects on the other ship which can be brought in range (vertically) for the correct distance, provided the observer always stands at a fixed point. A little pitching may seem to throw this out, but with practice the mean bearing can be recognized. Even at night, if the weather is reasonably clear, this plan is helpful, the spars and funnels of a ship 400 yards away being plainly visible with good binoculars.

It is sometimes practicable to use a mark on our own ship as a means of determining when we are at standard distance from the next ahead, the observer standing always at a fixed point and bringing this mark into coincidence with the water-line or some other well-defined mark on the other vessel. The objection to this is that such a mark would probably not be available in action and is thus worse than useless as a guide at other times. It may be possible, however, to fix a line on something which is always available. An officer looking through a slit in the conning tower, for example, might be guided by the angle subtended by the width of this slit—either vertically or horizontally—his eye being at a fixed point from which this angle just takes in the height of a funnel or the width of a bridge on the ship ahead.

It is important to recognize the effect of *steering*, upon the speed of the ship. A poor helmsman may make it impossible for any officer to keep position. Not only does the ship in steering wildly range over a greater distance than is right, but the "drag" of the rudder holds her back and reduces her speed very materially. It is worth while to give great attention to training the helmsman, insisting not only that a steady course shall be kept, but that this shall be kept with the least possible amount of helm.

It is a common error for beginners to make too frequent and too radical changes of speed as a result of the failure to allow for the interval which necessarily elapses between the signal for increasing or reducing the revolutions and the actual change of speed and position to be produced by the change in revolutions. It is realized that a large ship holds her way for a long time after the engines are stopped, and that she does not gather way, if at rest, until an appreciable time after the engines are started;

but it is not always realized that exactly the same delay must be allowed for in the response to a change of a few turns when the ship is already making way. Thus the beginner, impatient to regain position, and seeing no effect from his signal to add or subtract one or two revolutions, is tempted to call for two or three more; and when, finally, the ship begins to forge ahead or to drop back, his inclination is to let this go on until he is nearly or quite in position, forgetting that the effect of the change in revolutions of his engines will continue to affect the speed of his ship long after the engines have resumed their standard speed. This leads, of course, to almost endless changes in the revolutions and keeps the ship perpetually ranging ahead of position and dropping back astern of it.

Assuming that a ship has dropped astern of position, say a hundred yards, and wishes to regain her place.[1] Having steadied her, it remains to regain position and to avoid overrunning. Suppose that five revolutions correspond to one knot. This means that five revolutions per minute will give 2000 yards in an hour. One revolution will thus give 400 yards an hour, or 100 yards in 15 minutes. If, therefore, we add one *to the revolutions which hold her steady*, we may expect to regain position in 15 minutes, which is much too long an interval. To reduce the time to five minutes, we must add not one turn, but three. We shall not be actually in position at the end of the five minutes, for it will take a perceptible time to pick up the extra speed; but the interval for continuing the extra revolutions will be five minutes, since it will take approximately the same time to run off the extra momentum that it took to pick it up, and the ship should, theoretically, settle into place with the speed which will just keep her there.

Similar considerations govern the reverse operation of dropping back when we find ourselves ahead of position.

In all changes of speed, and indeed at all times when working in squadron, it is not only good "comradeship" but good seamanship, to give all possible consideration to the next astern. It may be difficult for him to run into you, as is often said, but this is no reason for trying to make it easy for him to do so. If the

[1] It is the "doctrine" of the Fleet to do this *smartly* (See Notes *B* at end of this chapter) but the danger of overrunning, as above described, must not be forgotten.

next ahead comes dropping back suddenly upon you, and the next astern is rather closer than he should be, there is no harm in sheering out a little until all hands have time to adjust themselves. And in the simpler case where you are merely called upon to open out for regaining your own position, it is well to do this slowly, giving indication by speed signals of your intention to reduce revolutions. If you find yourself running up on your leader, you should of course sheer out onto his quarter until he draws away or you drop back.

It is an axiom of tactics that in column a ship is better ahead of position than astern of it. This is for the reason that by running more or less ahead she does not, as a rule, subject any other ship to inconvenience. The next ahead will not usually attempt to get out of the way, and the next astern is under no obligation to follow up. On the other hand, a ship falling materially behind her station crowds back the next astern and inconveniences all ships in rear.

It should be noted, however, that if too much emphasis is placed upon this axiom, there may be a tendency for all ships to close unduly, each on the next ahead, and this may result in congestion throughout the column or a considerable part of it; and while there is comparatively little danger in such congestion so long as a steady course is steered, the danger becomes very serious if the column changes course by more than a few points. If a signal for such a change is hoisted while a number of ships are crowding up on each other, it may be presumed that every ship will try to drop back, thus producing more or less confusion; but whether they attempt this or not, the difficulties of the turn will be much increased.

It is doubtless correct for a vessel which is ahead of position when the signal for a change of course goes up, to try to get into position before the turning point is reached, *but there is no excuse for the disposition frequently manifested to drop back, whether in position or not, to the maximum distance tolerated by tactical regulations.* If dropping back legitimately, it is very important to pick up standard speed—not in revolutions alone, but in actual speed made good—in time to make the turn with standard speed.

In compound formations there is especial reason for insisting that the individual columns shall not be lengthened out unduly,

because the rear of a column which is taking up more than its share of sea-room will crowd the head of the next column when the fleet passes into simple formation. In compound formations, therefore, we may place more emphasis upon our rule that it is better to be ahead of station than astern of it. And here, too, as there are fewer ships in the individual column, the results of congestion are less serious.

In spite of all precautions, interference will occasionally arise between the rear of one subdivision of the fleet and the head of the next one, in passing from one formation to another, and it is well to prescribe rules as to who shall give way in such a situation, and how. A convenient rule is to require the rear vessel of a leading section, when she finds herself so far astern of position as to embarrass the leader of the next section, to give way to the side of safety; letting the leader of the other division swing into his proper place, and continuing on herself, more or less outside the formation, until she finds a chance to work into place.

In running at night without lights, not only can the ship ahead be seen—though perhaps only very dimly—but her wake is likely to show up with more or less phosphorescence. The difficulties of this situation are less than is sometimes supposed. All must be ready for switching on the navigation lights upon the approach of other vessels, and for manœuvring to keep clear as required by law—except, of course, in time of war.

In a Fog.

Running in a fog has been much simplified by the adoption of "position-buoys." It is found well to keep the buoy of the ship ahead a little on one bow and nearly abreast of the stem. If each ship keeps an after search-light trained upon her own buoy at night, the situation is still farther improved. The search-light shows the buoy if it is "watching" and shows approximately where it should be, if it tows under for awhile. Moreover, the search-light itself can be made out for from 500 to 1000 yards through a very dense fog. Search-lights are useful by day as well as by night, and should be used at all times in a fog.

It is important to keep well closed up in a fog. If a ship loses touch, it is difficult to regain it.

Unless in case of an emergency, only small changes in course should be made in a fog. If the course is to be changed as much as four points, it is better to make two changes of two points each, allowing time between for all ships to get straightened out.

If danger of collision threatens with a ship outside the fleet, it must never be forgotten that the ships of the fleet are to be considered in any manœuver that is made for keeping clear. It is as indefensible in law as in seamanship to foul a ship of the fleet in keeping clear of an outsider. The ships astern may be relied upon to help keep clear as soon as they are notified by signal, but the signals provided for this emergency are far from satisfactory. In case of backing the engines, the International Signal of three blasts must of course be given instantly; but with the other signals that are always sounding in a fog it may be doubted whether this will be recognized as promptly as is desirable. In any event, the caution here given, to remember your own ships as well as the stranger, cannot be amiss.

Although the subject of avoiding collision in a fog is fully treated in another chapter, attention may here be called to the difference between the case in which one ship strikes another on the broadside, and that in which the two ships scrape alongside. The importance of this in connection with ships in squadron lies in the fact that all the ships are, in general, headed in the same direction, so that if one of them stops without turning very much, the next astern, coming up, if she cannot avoid touching, can usually manage to scrape alongside rather than to strike a direct blow. It might perhaps be argued from this that if a ship in squadron finds it suddenly necessary to go *full speed astern* to clear a stranger, she should try to avoid turning more than is necessary. The next astern, coming up, has thus the maximum chance of avoiding collision altogether or of striking a glancing rather than a cutting blow.

The question of speed in a fog is very fully discussed in Chapters XIV and XV.

Special sound signals are used for manœuvring in a fog. Those at present established are crude and unsatisfactory. It is probable that submarine signals and the wireless telephone will ultimately be substituted for them.

It is very important to have a good lookout at the bow and to provide efficient means of communication with the bridge. This

lookout should be able to see the vessel ahead at almost all times.

Breakdown.

A vessel which breaks down, hauls out of the column at once and should be very prompt in giving notice to the ships astern. Rules are laid down as to the side for hauling out, and breakdown signals are established.

An accident to the steering gear, if the helm is well over to one side, may make it necessary or advisable to haul out on the wrong side, in which case speed may be increased. The engines will, of course, be used for steering, and if the helm is not too far over to the wrong side it will be easy to swing against it by giving full speed to the off screw and so to haul out according to rule; but if the situation calls for slowing materially on the inner screw, with some delay and uncertainty in getting clear, it is better to keep up the speed and haul out on the other side.

In case the helm is jammed not far from amidships, it should be practicable to keep in position by the screws and so avoid showing the breakdown signal; but if there is any doubt about this it is well to fall out and avoid the danger of trouble.

It is very important to have everything ready for shifting quickly from steam or electric to hand-steering gear, or, if the accident does not call for throwing out the steam gear, then to shift from one steering-station to another, without nervousness or confusion. Capable men should be stationed in the steering engine-room at all times ready to meet any emergency, and the detail of men for the hand-steering gear should be considered quite as important as the life-boat crew. The lines of communication from the bridge to the various steering stations should be perfected, and kept always in working order. Finally, frequent drills should make it a matter of simple routine to meet any emergency connected with the steering.

Man Overboard.

Rules are prescribed for this as a tactical manœuver, and signals are provided for notifying the fleet. If the man goes over from the ship ahead of you, you should be able to see him as you run up towards him. By stopping at once, and backing if it seems advisable to do so, you should be able to bring him fairly

close alongside and to toss a buoy or a line close to him. It must be remembered that the *suction* of a screw continues for some time after the screw is stopped, so that if you are going to run beyond the man you must take care not to let him get near the screw until its wash has subsided. It is a pretty manœuver to bring the man alongside and pick him up with the ship, but unless the ship is practically dead in the water the wash alongside may be embarrassing, and if he goes down he may come up under the bottom. The life-boat will, of course, be ready and can be lowered very near him, and it is not well to take any chances that the man will keep afloat long enough for you to pick him up in any except the quickest and surest way, which will usually be by means of a boat.

Keeping Position in Line.

The most important requirement for keeping position in line is to be absolutely sure about the *course* of the guide. A slight error in this not only leads the ship which is in error to close or open distance without understanding why, but misleads her also as to her bearing. It is helpful to have conspicuous marks establishing a thwartship line *on the guide*, by which other ships may know, not only that they have her abeam, but that they are also abeam of her.

Battleships and destroyers are fitted with gyro-compasses and "repeaters," which, when used in connection with one-metre range-finders, greatly facilitate keeping position.

If out of bearing, it is better to be astern than ahead, because when the signal comes to form column it is easy to drop into place by easing the helm and slightly increasing speed.

If a ship which is in position as regards both bearing and distance forges ahead of the line or drops astern of it, she changes not only her bearing, but her distance; the distance becoming too great in either case—that is to say, whether she is ahead or astern of the line. Yet the remedy is merely to change speed, without working in or out with reference to the guide. If a ship, finding herself a little out of position as regards both bearing and distance, attempts to correct these two elements by changing two variables simultaneously—closing in toward the guide, for example, at the same time that she drops back toward the proper bearing—it is impossible to foresee just how she will come out.

It is much better, assuming that the total error is not very great, to correct one element at a time, and to begin by getting on the proper bearing, after which it is not difficult to close in or open out by a small change of course and speed. It should not be necessary to change the course more than one-eighth of a point, or at most one-quarter of a point, and tables can be prepared to indicate the change of speed which will hold the vessel steady on her bearing as she heads in or out by this angle. The use of a definite angle here, with the definite change of speed indicated by a table, removes the problem from the realm of guess-work to that of rules; although here, as in all other cases of handling a ship, the rules must always be illuminated by judgment.

It should be observed that any change of distance in line calls for an *increase* of speed, whether it is a matter of closing-in toward the guide or of opening-out from her.

Attention has already been called to the value of steaming in line as a matter of training for steaming at unvarying speed.

On an Echelon Line of Bearing.

For keeping position in echelon, it is even more important than in line abreast, to be sure of the exact course which the guide is steering. It is helpful, if practicable, to have marks on one's own ship, fixing the line of bearing, which will almost always be either two, four, or six points on the bow. Here, as in the case of line formation, the gyro-compass and repeaters, with the small range-finders, greatly simplify the problem of keeping position. The essential point is to so place the observer that he may—always under the general direction of the officer of the deck—watch the bearing and distance and regulate these by a touch, from time to time, of the helm or the revolutions.

If open slits are used in the conning tower, the sides of these, or light colored marks painted on them—the observer's position being fixed—give a convenient line when conning from this point, if nothing more satisfactory is available outside.

Here, as in the case of "Line Abreast," it is well, if a little out of position, to correct the bearing first, and then the distance, thus using only one variable at a time. There is this difference to be noted between echelon and line abreast as regards a change of distance. It has been explained that in line abreast, any change of distance on the guide calls for an increase of speed, whether

to close in or open out. In echelon, to close in toward the advanced flank calls for an increase of speed (to hold the bearing steady) and for a greater increase than when in line. But to *open out* in echelon, while keeping the bearing steady, *calls for a reduction in speed.* To work off toward the withdrawn flank without reducing speed would throw us ahead and more or less across the bow of the vessel next toward the withdrawn flank. The importance of this point increases as the sharpness of the line of bearing increases; that is to say, as the echelon departs more and more widely from line abreast and approaches more and more closely to column. When the withdrawn flank is dropped back eight points—forming column—all change of distance becomes entirely a matter of change in speed.

To Change Course in Succession in Column, Turning Eight Points or Less.

One of the most important difficulties connected with the manœuvring of ships in squadron arises from the uncertainty which inevitably exists at any given time with regard to the tactical diameter of any individual ship under the conditions of trim and of weather existing at the moment.

Turning trials are often made so hurriedly and under such unfavorable conditions, as to be of little value at the best; and even when they are made with every care, in a smooth sea and with little wind, they give results which are standard only for similar conditions, and which will vary widely with variations in draft and trim, and in wind and sea.

It should be added that the methods which are in use for determining turning circles and other tactical data are crude and unsatisfactory and it is greatly to be desired that some more scientific method should be devised and put into effect under rules which will not only permit, but require, the accumulation of complete tactical information with regard, at least, to every man-of-war which is ever expected to manœuver in company with other ships.

When all has been done in this direction which can be done, and absolutely exact information acquired, the fact will still remain that the tactical diameter of a ship when trimming by the stern will be greater than when she is on an even keel, and much greater than when she happens to be trimming by the head. Similarly the diameter of a ship which at a given time is trim-

ming by the stern will be materially greater when she is turning up into a fresh breeze than when she is turning away from it. The effect of these and similar variations of condition makes it impossible to say of any ship except in a very general, and often a very misleading, sense, that her tactical diameter is a fixed number of yards for a fixed speed *and a fixed helm angle,* and then demand that the ship shall under all conditions, turn in a circle of this diameter, using a standard helm angle prescribed as the result of trials made with one particular set of conditions.

For a given standard circle—which is what is desired in manœuvers—the helm angle must of necessity be varied from time to time within certain limits, and it is the judgment shown in this variation which makes the difference between success and failure in squadron work.

In making a turn, the leader of the column should be scrupulously careful to use the same helm angle at all times, to put the helm over to this angle in the same interval of time, to ease the helm and reverse it always at the same point of the turn. It is particularly objectionable for the leader to swing past the new course and then come back to it. And the leader should make no change in revolutions during the turn, unless to avoid danger.

The other ships of the column must adapt their circles to the standard thus established by the leader, their problem being to follow around in his wake, preserving the formation as accurately as practicable.

To put the helm over at the right instant and by just the right amount calls for good judgment, and, it would almost seem, for a special instinct. Many officers believe that the difficulty here is best met by noting the instant when the next ahead begins to turn, and adding to this a time-interval calculated beforehand for speed and distance. This seems reasonable, but is not usually found satisfactory in practice. The bearing of the next ahead, or of the second ahead, should be helpful, but this again is found to fail in practice. Perhaps the most satisfactory guide, when it is available, is the path of the ship ahead as marked out by the broad sweep of the wake which she leaves in turning. This starts with a pronounced "kick" toward the off side, where the stern has swung over at the beginning of the turn, and continues as a broad curving arc of disturbed water one side of

which marks the path of the stem, the other that of the stern. Practice will make it possible to judge with fair accuracy how far the bow of the following ship should be allowed to enter this wake before the helm is put over, but it must not be forgotten that a fresh breeze blowing across will carry the wake to leeward, and that at night the wake cannot always be distinguished. Moreover, it is at the best, only a guide for turning in the wake of the next ahead, and she may have turned very wide of the leader.

There is no question that the officers who are most successful in this manœuver rely upon the general "look" of things ahead rather than upon any rules which could be formulated for the help of others;—in other words, they more or less unconsciously sum up a number of factors and are guided by the balance of all rather than by any one alone.

A ship well down toward the rear of the column cannot govern herself directly by the leader. She has, however, a good view of the ships ahead, all of which, except the one which has last turned, may be assumed to have corrected any errors made in turning, and to be now following in the leader's wake. Carrying back the line formed by these ships she should be able to judge fairly well how her next ahead is coming out, and to determine whether to turn outside or inside or to follow around as exactly as she can. The difficulty here is far greater by night than by day, and is enormously increased when lights are screened.

It is important to watch the steering after the next ahead begins to turn, *and to take care that the ship is held on her compass course and not allowed to swing off, following the "kick" made by the stern of the ship ahead.* It is helpful here to glance at the ships astern, which are still, of course, preserving the old direction, thus getting a line by which to make sure that your helmsman is not swinging off in spite of good intentions.

It is better to start the turn a little early rather than at all too late. If the bow is pushed too far across the wake of the ships ahead, it catches the current from their screws and is thrown off still more, with the result that a small initial error is greatly magnified. A ship which turns *outside* must accept the situation and straighten out on a course parallel to the column and outside of it. To attempt to work into position across the bow of

the next astern while the latter is turning would involve danger of being rammed. It will be necessary, after having turned outside, to increase speed a little, thus making up for the larger circle traversed. A ship which finds herself turning *a little* inside could correct the error by easing her helm and reducing speed slightly, waiting for this until the turn has progressed to a point where the condition of affairs can be made out with certainty; but most officers think it unwise to tolerate this, if only for the reason that it is likely to encourage the *altogether unpardonable practice* of turning decidedly inside and then easing the helm, merely to avoid the embarrassment of judging when and where to turn properly; or the equally unpardonable practice of "cutting corners" to make up distance.

A ship which has turned inside will usually have to reduce speed more or less to drop into her position, but must resume standard in time to avoid hampering the next astern.

The time for easing the helm and reversing it to meet the ship on her new course will vary with different ships. It is generally found well to begin easing at about two points from the course, bringing the helm to amidships with one point left to go, and then to reverse it as much and as fast as is found necessary to meet her without swinging past the course. It is especially important for the *leader* to be absolutely consistent in this matter.

Each ship before turning should note carefully what her new compass course is to be.

Finally, attention may be called to the importance of being always as nearly as possible in position, as regards both bearing and distance, before beginning to turn. To be outside or inside of the point where the leader has put the helm over means an outside or an inside turn—if we assume that the helm used is that which duplicates the turn of the leader. A still more important point is that the ship should be *steady on her proper course* when the time comes to put the helm over. *If she is off her course or if she is swinging, a variable and uncertain factor is introduced into the turn.* It is important also that the speed should be uniform and standard. If a ship is closing up or dropping back as she approaches the turning point, even though standard speed be ordered at the last moment, she will continue to gain or lose distance throughout the turn.

It is not necessary to point out the exceptional embarrassment which may result from being very close to the next ahead and on her inner quarter when she begins to turn. This situation may arise from the next ahead being out of position, in which case it emphasizes two of the rules which have been laid down above; first, that it is better to be ahead of position than astern, since by being ahead you embarrass nobody but yourself, and second that it is good seamanship as well as good comradeship to avoid embarrassing your next astern. If, on the other hand, it is a real error of position on your own part, it emphasizes the caution already given not to overwork the first of these two rules by making a practice of being ahead of position.

Turning More Than Eight Points.

In a turn of more than eight points it is very dangerous to turn inside. A ship which finds herself in this position should reduce speed in the early part of the turn to avoid running up on the next ahead, whom she will presently find swinging in across her bow as the column doubles back toward its original line. The best that she can do is to keep turning, at reduced speed, and with *hard-over* rudder, abreast her proper place in the column, but always inside of it. There will be a temptation to work back into place by easing the helm, but this will check her swing and she can never pick it up again. The result is that if she gets into place momentarily, it will be only to cut across the curve on which the other ships are turning, and, worst of all, to receive a kick from the screw current of the ships ahead on her inner bow, throwing her still further out and more or less across the stem of the following ship, which, swinging as she will be under hard-over helm, is practically powerless to do anything toward keeping clear of a ship in such a position.

The only thing to do, then, is to turn on a circle parallel to that of the column, but with smaller radius. This means a sharper turn and calls for more than standard turning helm and possibly for stopping the inner screw. Here, as in the other abnormal situations, due notice should be given by the cones or otherwise, of all changes of speed. The next astern can, in case of danger, help to keep clear of a ship which is distinctly inside of her, by easing her helm.

A ship turning *outside* the proper path is safe but needs a

material increase of speed to keep abreast of position. The danger of attempting to work into place in the column is even greater than in an eight-point turn, so there is nothing to do but to keep up as well as possible and be ready to resume position after the turn is completed.

The difficulties and dangers of a "counter-march" are so many and its utility is so slight that in some fleets it has been given up, its place being taken, when a change of 16 points is to be made, by two 8-point turns.

Turning Simultaneously.

To turn simultaneously through 8 or 16 points is a test of many points in the work of the squadron; since any error in position, speed, or tactical diameter is brought out very strikingly. In one respect, the apparent result may be misleading, since the guide now changes (usually) and it may happen that ships which were exactly in position with the old guide and which have turned perfectly, are altogether out when the turn is completed, as a result of faults on the part of the new guide.

As soon as signal is made for this or any other manœuver which involves a change of guide, each ship should try to get her distance and bearing from the new guide so that she may know where she is likely to find herself at the end of the manœuver, and what will be necessary for getting into position. By watching the guide as the end of the first eight points is approached and completed, much can be learned about the way the ships are turning with reference to each other, and this is a good time also to get the distance, if practicable. The adjoining ships on either hand should also be watched, as intervals are sometimes closed rather unaccountably in a turn of this kind, and ships run up dangerously close without clear evidence as to which one is at fault. (See remarks below as to reasons for variations of speed in the turning of different ships.)

As the new course is approached, certain allowances must be made (unless prohibited by tactical regulations) to perfect the alignment on the new guide.

It is a fact often noted in fleet manœuvers where vessels of different type are associated, that some ships lose much more speed than others in turning. There are several reasons for this difference. With ships of different length, but otherwise simi-

lar, the longer ship will expend a larger proportion of her power in turning, and thus her speed will drop more than that of the short ships. A ship with full deadwood aft expends more power in turning than one with the deadwood cut away, and therefore loses more speed. A ship with large turrets or other heavy weights at bow and stern requires more power to take up her swing at the beginning and more power to check it at the end, than one whose weights are more evenly distributed, and will thus have less power left for maintaining her speed.

For the above reasons, it is very important to group similar vessels together as far as possible.

Anchoring Simultaneously.

In standing in for an anchorage it is customary to slow to five or six knots while still some distance away and to stop when at a distance such that it is thought the ships will reach up to their berths with sufficient way left for anchoring. Supposing all the ships to be in position and moving at uniform speed when the fleet is stopped, it is assumed that they will continue in position. Unfortunately, this is not the case unless, as very rarely happens, they are all of the same displacement. Nor does it always happen that all are running at the same speed when the signal to stop is hauled down.

In running 500 yards, very marked changes of position may take place in a fleet where the displacement varies as much as it commonly does in most fleets of to-day or where some variation of speed exists at the instant of stopping. It is worth considering whether it might not be well to keep the engines turning over at dead slow up to the instant of letting go the anchors. This would make it possible to keep the ships in position, and their headway need not be greater than it usually is under the present practice.

It is important that "half-speed" and "slow-speed" should be standardized as carefully as "standard speed" and that the leader of the column, when indicating either of these speeds, should maintain the proper number of revolutions as carefully as at other times. A little carelessness on the part of the leader when approaching the anchorage can make serious trouble for the ships astern. Similarly, of course, carelessness on the part of any ship in the column throws out all ships astern of her.

Getting Underway.[1]

ing been given in advance, of the hour for getting gnal is made a few minutes before this hour to " and, at the proper time, to "get underway." If ice to be heading in the proper direction, and if the her vessel which is to lead out of harbor is at the olumn, the manœuver is very simple. If the ships n some other direction, they should keep this head- anchors are up, until signal is made to turn. If the the inner end and proposes to lead out, it is advis- onditions of wind and tide introduce some difficulty, to turn a little short of the course on which they will is to say, they should head one or two points toward which the flagship will pass as she leads out. Each eady to drop into place as her turn is reached.

more common to see ships slow about getting into to see them closed up too far, the result being that ing port the leaders are often seen running at half he rear vessels are closing up under reserve speed. dly and there is no reason for it except undue slow- ity about taking position.

Handling Turbine Ships.

of-war of recent design have turbine engines, and lled somewhat differently from ships with recipro- s. Attention may be called to the following points :

ips have small screws, which are run at high speed. reciprocating engines the conditions are reversed, aving large screws which run at comparatively low

cannot be reversed, it is necessary to provide sepa- or backing; and as it is not economical to divide space equally between the power for going ahead backing, it results that the backing rotors are com- all.

[1] See Notes *B* at end of chapter.

In many cases turbine ships develop less than half the power in backing that they have for going ahead.

This is a point that can never be lost sight of for a moment when manœuvring in formation with ships having reciprocating engines. It is also of great importance in crowded waters or in a fog, in turning in a narrow space, in going alongside a dock, and in many other situations where it may be necessary to reduce the headway quickly.

Perhaps the most important loss which results from these conditions is in the power to turn in a limited space, where a ship with reciprocating engines and a good spread between her (large) screws can often be made to spin around on her heel by going ahead on one screw and backing on the other.

As it is necessary for reversing in a turbine ship to shift from one set of rotors to another, there is considerable time lost as compared with a corresponding shift in the case of reciprocating engines. It is found on the *Nevada* that, under average conditions, about a minute and a half is required.

As the head of steam is reduced in shifting from one set of rotors to another, there is a material drop in pressure where much manœuvring is called for, with the result that a ship which is obliged to shift several times in turning, as may be necessary in getting underway with other ships, is likely to find herself unable to pick up speed promptly after straightening out on her course. This may be guarded against by having a good reserve of boiler power.

There are two distinct types of turbines in use in the U. S. Navy, viz.: The Parsons and the Curtiss.

The following notes refer to ships having the Parsons type as installed on the *Florida* and *Utah*.

There are four propellers driven by turbines on each shaft. The high-pressure ahead rotors are on the wing shafts, the intermediate and low-pressure on the centre shafts; the high-pressure backing rotors are on the wing shafts, the low-pressure backing on the centre shafts. The backing turbines are small and the combination has less than half the power of the ahead combination. Due to the less efficient clearance of the blades, the backing turbines use up steam very rapidly and therefore the backing efficiency of the engines is really less than the rated

horse-power of the backing turbines would lead one to suppose. It should be noted also that after backing for a comparatively short time there is not a full head of steam left for going ahead until steam is worked up again.

Getting Underway. When getting underway the low efficiency of the backing turbines must be kept in mind at all times.

When casting in restricted waters the sternboard should be made towards the most restricted area on account of quicker effect of the propellers in going ahead.

The turning effects of the propellers in combination with the rudder are the same as with reciprocating engines, but slower. The effect of wind is the same, the ship usually falling off when going astern.

In a tide-way it is most important to bear in mind that the ship responds to her engines much more slowly than in the case of reciprocating engines with large propellers, particularly in backing. With way on ahead the ship answers her rudder practically as efficiently with her engines backing as when they are stopped or going ahead.

When getting underway in squadron where it is necessary to gain and keep position, it is well to remember that much manœuvring in turning materially reduces the head of steam, and it will be necessary to work it up again before full or even standard speed can be maintained. A very wise precaution is to have more power available than the prescribed speed requires until clear of the harbor, when a boiler may be taken off.

Coming to Anchor. When approaching an anchorage the low efficiency of the backing turbines must be kept in mind always. With steam for fourteen knots or under it is not advisable to let go the anchor with more than four knots way on. The engines should be stopped far enough from the anchorage for the ship to lose her headway to about four knots when the anchor is let go. This gives the fire-room force opportunity to bottle up steam for backing. It is well to remember that when steam is shut off from the rotors the propellers revolve freely, so there is no drag of the propellers to deaden headway. Headway may be deadened by quickly putting the rudder full over each way. If the harbor is an open one it is well to keep standard speed to the point

where the engines should be stopped and let the ship slide up to her berth, rather than slowing gradually by two-thirds and one-third speed and then stopping near the anchorage point.

Cruising and Manœuvring in Formation. It must be borne in mind always that the ship responds slowly to changes of speed of the engines. The propellers are much smaller than in case of reciprocating ships with two screws. When cruising in formation with ships having reciprocating engines, their comparatively quick changes of speed must be taken into account and their action anticipated as much as possible. If astern of a reciprocating ship and the signal stop is made, the turbine ship will close up rapidly.

When turning, the rudder tends to check the speed materially and distance must be watched closely. If it becomes necessary to give more than the standard rudder in the turn, the engines should be speeded up immediately. If the rudder is put over full, the ship will lose distance rapidly in spite of full speed on the engines. Therefore it is better to turn outside than to attempt to turn short into column with a full rudder.

When manœuvring in company with reciprocating ships very great care and vigilance are required at all times, and the rudder should be depended on rather than engines in avoiding collision.

In a Fog. In a fog also the rudder must be relied on rather than the engines. The rudders are large and the steering qualities excellent. Stopping and backing the starboard engines when turning to starboard, and the port engines when turning to port, of course will quicken the turning very materially. Headway is lost slowly by backing the engines, but quickly by using full rudder.

Breakdown. The ship will carry her way a long time, as the propellers do not drag. Headway will be lost quickly by using a full rudder in turning.

Man Overboard. Rules are prescribed for this as a tactical manœuvre. But when acting singly or otherwise, when possible to do so, the quickest way to reach the man is to turn with a full rudder, stopping engines until the man is clear and then starting them again. Keep engines going until about half-way around, then stop. The ship will slide up close to the man and headway will be deadened enough to get boats away.

The following notes refer especially to Curtiss turbines.

ks on Parsons turbines apply also to Curtiss turbines where a ship has four propellers. In oil-burning ot necessary to make allowances for time to build essure for going ahead again after backing, even team pressure has dropped due to the large volume uired for backing. This is due to the fact that as fire-room receives the signal "Full speed," enough at once turned on to run the steam quickly up to pressure. The point is that the volume of oil flame ilers can very quickly be varied at will, which is of ie case with vessels burning coal.

evada, which is equipped with only two propellers turbines, the time required to manipulate the neces- for stopping and backing is practically constant for This time is from fifteen to twenty seconds. But erval of time elapsing from going ahead—say at —to astern, depends entirely on the boiler power Vith full boiler power it would not take more than o reverse the engines from full speed ahead. With rd boiler power available (which is the minimum) t two minutes to reverse and have the *engines* going ern. With one-half to two-thirds boiler power avail- ½ minutes would be required to back at three-quar- cimum astern speed.

ower available.	Engines going ahead.	Engines going astern.	Elapsed time.
boilers)	Full speed	Full speed	1 minute
oilers)	15 knots	¾	1½ minutes
inimum for backing.	5–10 knots	½	2 minutes

The above times are approximate.

speaking, the turbine ship having two propellers can iore quickly than the turbine ship having four pro- : it takes less time for the steam to pass through the d since the propellers are somewhat larger. How- al backing power is about equal in both Parsons and llations.

ng. Vessels of the *Nevada* class have their deadwood ich more than other recent types. This results in im-

proved tactical qualities, but this improvement tends to complicate, rather than simplify, the handling of the ship in formation with the older ships, such as the *Wyoming* and *New York* classes. The reason for this is as follows: Absence of deadwood has very little effect as long as the ship travels a straight course, but as soon as she begins to turn she turns very rapidly. This causes the ship to advance much further than the older ships when given the amount of rudder necessary to turn in the same tactical diameter. Conversely, if she is given enough helm to cause her immediately to follow in the wake of one of the older ships, she will describe a much smaller circle. Thus the vessel cannot be turned *in a prescribed tactical diameter* by using a standard helm without getting considerably out of position. That is, a varying amount of helm must be used in manœuvring with the older types of vessels.

Another peculiarity of this ship is the difficulty of steering with the engines. There being but two propellers, which are small (18 ft.) and set close to the center line (24 ft.), their steering effect is almost negligible. In fact, if the ship is swinging it is practically impossible to check her with the engines alone. At slow speeds, when there is considerable wind and sea, the ship has a strong tendency to come up into the wind, and it is often necessary to steam under one engine and with a considerable rudder in order to steer a set course. In a harbor, with little manœuvring room, and with but little way on it is difficult to turn against the wind. This condition is probably found only on the *Nevada,* since her sister ship, the *Oklahoma,* has reciprocating engines, and the later types, *Arizona* and *Pennsylvania,* have four screws.

In a Fog. Backing the inboard engine when turning with full rudder does not quicken the turn, but causes the ship to advance fifty yards less and transfer fifty yards less than when turning with full rudder and both engines going ahead. There appears to be a slight advantage in backing the inboard engine to avoid collision, though the headway is much reduced by the time the ship has turned 90°.

Man Overboard. There is no necessity for stopping the engines to prevent striking a man overboard. In the first place the tops of the screws are submerged 11 feet and the outboard edge does not project beyond the side of the ship; in the second place the screws continue to revolve for some time at practically the same speed

after the throttles are closed, provided the ship has way on. The best thing to do is to manœuvre to lower a boat as soon as possible and as close as possible to the man. By using full rudder and turning 180° with both engines going ahead and then backing both engines the ship will be practically dead in the water at the point where the rudder was first put over.

In other respects the manœuvring qualities of the *Nevada* are similar to those described for the *Florida* and *Utah*.

Notes On Handling the Idaho.

Steering. The *Idaho* has electric and steam steering gear, the shift from one to the other being made through clutches in the steering gear room. Frequent drill enables the steering room watch to shift in thirty seconds or less after hearing the bell signal from the steering station. In order to be sure that both systems are at their maximum efficiency it is customary to use each system twelve hours out of every twenty-four hours at sea.

The *Idaho* has Parsons Turbines, four shafts. Her engines are used in "Direct Combination" or "Cruising Combination." The direct combination may be used for all speeds and is best for manœuvring and backing. It is the only combination for speeds over seventeen knots. The cruising combination may be used for all speeds up to seventeen knots and for manœuvring and backing, though it is more awkward than the direct combination due to the fact that a small high pressure turbine is connected to each inner shaft by a mechanical gear, which is thrown out for the direct combination. Backing reverses the motion through the gear, which is more awkward than if the gear were not there. Practice is to get under way, manœuvre, and come to anchor, with the direct combination, though the Pacific Fleet is considering an order making it mandatory to use the cruising combination for all speeds under a certain designated one.

To shift from direct to cruising combination requires one minute fifteen seconds, varying somewhat with the speed of the ship. The shafts have to be stopped to make this shift. It is best to back before making the shift so as to prevent the main shafts turning due to headway.

To shift from cruising to direct combination takes thirty seconds, varying somewhat with the speed of the ship. Clutch can be disconnected with shafts revolving slowly.

Time necessary to reverse from fifteen knots ahead to full speed astern is about ten seconds when in direct and fifteen seconds when in cruising combination. The relative backing to ahead power is about seventy-five per cent.

Handling of Ship. The two shafts on the same side work together and it is only necessary to think in terms of the starboard and port engines. The *Idaho* handles like any twin screw (out turning) ship except that she does not answer as readily. It is difficult to get any results unless there is way on the ship. To get results in turning it is better to use standard speed on the ahead engines and full speed on the astern engines than it is to use one third and two third speeds.

Turning Eight Points or Less. The rudder is first put over a little more than standard to get the ship started. After the ship has turned a given amount, depending on the amount of the turn to be made and determined by experience, the rudder is eased to standard. It is then put amidships and reversed in time to keep the ship from swinging past the course.

Except as above noted, the remarks which precede as to handling turbine ships apply to the *Idaho*.

Notes on Handling the Jupiter.

Before discussing the handling of the Jupiter, it will be necessary to give a brief description of the installation.

The ship is propelled by two induction motors using alternating current furnished by a turbine-driven generator. So far as the generation of power goes, the *Jupiter* is a single-screw ship, as all power used by the motors comes from the one generator, which is driven by one turbine; but so far as manœuvring goes, she is a twin-screw ship, as the power is carried from the single generator to two motors and two shafts.

The generator has two poles and each motor thirty-six poles, so that eighteen revolutions of the generator are necessary for one revolution of the motor, which is secured to its respective propeller shaft. In other words, the propeller revolutions (neglecting slip in the motor, which is less than 2%) are always one-eighteenth of the number of revolutions of the revolving field of the generator.

The revolving field of the generator is on the same shaft as the rotor of the turbine so that one revolution of the turbine gives one revolution to the generator and 1/18 of a revolution of the motors and propellers.

Thus, in order to change the speed of the propellers, it is only necessary to vary the speed of the turbine which drives the generator; and all changes of speed in the vessel are made in this way. In other words, if the turbine and generator are making 1800 r.p.m. the motor will make 100 r.p.m., which gives thirteen knots. If the turbine is slowed to 900, or one-half the revolutions, the motors automatically, due to their construction and to the fact that they are induction motors, will make 50 revolutions, or speed for six and one-half knots.

Object and Effect of Resistances. There are two water-cooled resistances in the engine-room which can be thrown in or out of circuit with the rotor of either motor, and as these are cross-connected they must be thrown in or out on both motors at the same time.

These resistances have nothing whatever to do with the speed of the motors and propellers. Their function is to enable the motors to exert their go ahead or backing power on the propeller shaft *instantaneously*. The effect of these resistances is, in fact, to give the motors and propellers a practically instantaneous full-power reversal in either direction, either at fifteen knots or at any speed below that, the *speed* at which the motors operate when the resistances are "in" depending entirely upon the speed of the turbine and the generator field, as has been stated. It takes about four seconds to throw these resistances in or out of circuit.

As the motors are less economical running with the resistances "in," they are habitually kept "out" except in manœuvring where instantaneous reversal is desirable.

If running at a speed of fifteen knots, the highest speed the vessel can attain, the resistances can be thrown in and the motors reversed up to a speed of ten knots, in four seconds. Either motor may be stopped while the other is running in either direction.

Turning. A point that forces itself upon one's attention, and a vital one so far as manœuvring goes, has to do with the turning of a vessel, the motors (and propellers) of which must of necessity operate at the same number of revolutions whether both are

going ahead or one is going ahead and the other astern. As a matter of fact the difficulties which might be expected to result from these conditions vanish under the test of actual manœuvring. The turning of the ship is accomplished by the application of power to the propellers in different directions, for certain periods of time. Consider the *Jupiter* turning to the right with full right rudder at 10 knots (77 r.p.m.) under the port motor, starboard motor being stopped. It is desired to turn faster. The starboard motor is signalled to back; and a second after the switch is thrown, that motor is making seventy-seven revolutions,—no more and no less,—astern. The ship picks up to the desired velocity. The signal is given to stop the starboard motor, and instantly the power is off. The inertia of the ship overcomes any jerky motion. In other words, with two motors that can supply absolutely definite amounts of power to the propellers as often as thirty times a minute, any uncertainty as to what is going on is removed, and greater facility of control attained.

It is one thing to have an order appear on the engine-room telegraphs and quite another to obtain an absolutely definite and practically instantaneous response. The handling of the *New Mexico,* when both pairs of motors are operated from one of her two turbo generators, will be similar to that of the *Jupiter;* but when the starboard and port pairs of motors take their power from separate turbo generators, of which there are two instead of one as in the *Jupiter,* the starboard and port pairs of propellers can operate at different speeds as reciprocating engines do, but with much greater promptness. One should be able to "thread the eye of a needle" with the *New Mexico* if the two independent turbo-generators are in use.

Fleet Work. The manœuvring of the *Jupiter,* as required by the nature of the duties she must perform, is somewhat more complicated than falls to a reciprocating engine battleship, for the reason that the *Jupiter,* which displaces 22,000 tons, draws 31 feet when fully loaded, and as little as 20 feet when nearly discharged. She is 542 feet long, has only 65 feet beam, and has a considerable amount of top hamper, making the effect of wind a very important factor, especially when the ship is light.

Moreover the full horse-power is 7200 or about ⅓ H.P. per ton of displacement, which is about a third of that at the dis-

posal of a reciprocating engine battleship. As the cargo is discharged, the ship is habitually trimmed down with water ballast; and for best handling trim a drag of from three to four feet is kept. If trimmed deeper by the stern, the wind effect on the bow resembles that upon a destroyer, and with the overhanging
nt of danger is introduced which calls for extreme
ıg alongside ships or coal piers.

side a Battleship. In illustrating the procedure of
le, the *Texas*, which is a clear-sided vessel and
e *Jupiter*, will be considered, and special difficulties
nnection with other vessels will be briefly mentioned

d that the *Texas* is anchored and that no obstacles
an ideal approach. Standard speed for going
n knots; no reserve speed is provided for, as all
ne well below the ten-knot limit.

roaching the battleship, pass under her stern and
ass heading by a bearing of her masts when in
is necessary because the *Jupiter's* bridge is far
t is difficult to judge the exact angle of approach.
curved form of the battleship is deceptive, and
ges of viewpoint frequently occur as the two ves-
close proximity.

he collier about 1,500 yards from, and two points
arter of, the battleship, the collier to be practically
ter at this time and on about the same heading as

e collier ahead with the motor, using ⅓ speed or
to give her steerage way, *and nothing more than*
then stop motors. Approach at steerage way,
nes as necessary. Avoid getting any more than
on the collier, as a moderate speed is no longer
n the vessels draw together; and if backing be-
ry, the control of the collier may be lost. Always
tion so in hand that you force the vessel to the
ever allow yourself to get close aboard and abreast
g to backing *both* engines to make a safe landing

lly change course so that your ship approaches
at an angle of one point. This keeps the sterns

of the ships separated and places the bow closer than any other part of the collier. Any effect of wind or current tends to set you slowly in; and besides this, if the battleship swings stern to starboard you can haul off a point and still be parallel, without getting the stern in and bringing the propellers of the two vessels together.

(5) As soon as the vessels are within heaving-line distance, pass your lines aboard; or if a boat is available, send over a heaving-line bent to a good hauling-line. By this hauling-line the bow-line and a spring are run simultaneously and carried as far forward as possible on the battleship.

(6) Work your ship parallel to the battleship, make fast the spring leading forward, tend the head-line, and if any current is running the collier will drop alongside; otherwise back 1/3 speed on port motor to assist. The advantage of using a spring leading forward, over one leading aft, is that the resultant of the wind and current forces, to which the battleship rides, all tend to make the collier do likewise. Moreover, less engine power is required to get alongside, the strain on the spring is taken on the battleship's anchor chain, and there is no tendency to tow her up towards her anchor, as with a spring leading aft, when the collier is forced ahead.

(7) Get stern lines over as convenient, but there is usually no urgency in this matter unless a wind blows from the battleship. Get out a spring leading aft from a point well forward, and place hatches as desired by the battleship. Never bother as to where the hatches will come till you are safely alongside and suitable lines are run to control the ship.

(8) Sometimes while close alongside, delay occurs in getting lines over. Pick out a mark on the battleship, say an awning stanchion, and hold the ship in position till lines are run.

The Broadside Landing. It sometimes happens that a wind of force four or even stronger is blowing you down, broadside, upon the battleship to which you must go. Under these conditions it is advisable to get abreast of the battleship and parallel to her, but outside of heaving-line distance. No strain should be taken on the bowline or bow spring when run, but the slack should be hove in as the collier drifts down. Keep the bow *out* about a quarter of a point and allow the after-fenders to take before the forward

ones. If any current is running and the wind sets the collier toward the battleship, it is hard to work the bow out against them. If the bow blows down rapidly let go the port anchor, to check her. Conversely it is well to be prepared to pull the bow out when the wind is blowing *from* the battleship when coming up from astern; for the bow of the collier is then under her lee while the stern is not.

Getting Clear. There is some difference of opinion among officers commanding colliers that do fleet work as to whether "backing away" or "going ahead" is the better method of getting clear of a battleship. It is usually to "Go ahead," if possible, for the following reasons:

(1) The pivoting point of the *Jupiter* is about ¼ of her length from the bow; it is therefore much easier to throw the stern clear than the bow, if in danger of contact.

(2) The bow is allowed to fall off not more than half a point before going ahead; and in this position any current tends to separate the vessels; and if the wind is ahead, that acts in the same direction. A short spring is used from a point forward of the propeller, where it cannot foul. This is kept fast while the bow is falling off, and run in when the collier starts ahead.

(3) When the collier starts ahead and the ships' sterns tend to draw together, backing the starboard motor throws the screw current, or "quick water," in between the ships, and first forces the stern away and then separates the vessels bodily. Of course the backing is only continued long enough to get the separating effect, and not long enough to materially check the collier's way. When starting away, set a course diverging not more than half a point from the battleship's heading, and throw the stern out with small right rudder; then back the starboard motor to separate ships, if necessary.

(4) The collier can then be gradually eased across the battleship's bow, keeping clear of her chain, and allowing for current if any.

(5) A vessel is under better control going ahead than while [illegible]d good control is essential in close quarters.

[illegible] **Away.** In using this method it is necessary to watch [illegible]llowing difficulties: In order to get clear, the stern [illegible] be worked off about half a point. This forces the flar[illegible] the collier close to the battleship.

The current, or wind, if the latter is from ahead, tends to force the bow towards the battleship.

Backing tends to back the stern into the wind, if it is ahead or on the port side, which increases the tendency of the bow to sweep the battleship.

By going ahead on the starboard propeller without stopping the collier's sternboard, a turning effect is gained; but as the pivoting point is well forward, this does not give as prompt or satisfactory results as are obtained in working the stern off in going ahead. Nevertheless no trouble need be anticipated in backing away, if care and skill are exercised.

Remember that the bow toward the battleship must pass her propeller before clearing, and, if too close aboard, may foul.

With a breeze blowing the collier toward the battleship, it is highly dangerous to attempt to back away.

Points to Keep in Mind.

(1) Never be in a hurry to get alongside—take it easy.

(2) If the collier handles badly, due to wind or other conditions, *back out while there is time.*

(3) When lines are run to a battleship, use as little engine power as possible. The vessels will come together quite rapidly enough. Do not force matters.

(4) Keep as large a reserve of power as possible.

(5) Coming up parallel to a battleship, then backing *both* engines, is dangerous. *Your starboard screw current tends to throw her across your bow, with her stern away from you.*

(6) Have both anchors hanging below the hawse-pipes and ready for letting go instantly, while working in the fleet.

(7) In going alongside a small vessel, ask her to heave short before you run lines. Let go your anchor and have her heave up at the same time. Then bring her alongside the collier.

(8) If by any chance the flaring bow overlaps the forecastle of a ship, and you fear that it may do some damage, go ahead full speed on the starboard propeller and back the port propeller full speed. Do not attempt to back away; you will sweep the battleship's side. Do not let the collier go astern. Hold your spring leading forward, bring the ships parallel, and then into position for coaling. If damage is done under these circum-

stances it will be less than will result from attempting to back out with wind or current setting you on.

(9) Be ready to get underway at short notice while alongside a ship.

(10) Trim your ship with water ballast as coal comes out, thus keeping her manageable at all times.

(11) Be on the lookout for a change of heading on the vessel you approach. She may swing unexpectedly.

Some Duties of the Officer of the Deck.

In concluding this chapter it may be helpful to call the attention of young officers to the magnitude of the responsibility which rests upon an officer in charge of the deck of a battleship at sea in company with a large number of other ships. Officers easily become so accustomed to the routine of cruising and manœuvring without accident, that they forget how close they may be at any instant, not only to accident, but to disaster.

It is not alone the mishaps of one's own ship which must be reckoned with, but those occurring to the ships ahead as well. It is true that if the next ahead stops her engines suddenly, she still holds her way for a time, and if the officer on her bridge is alert and self-possessed, he gives instant notice of the accident and hauls out of column. If the next astern is also alert and self-possessed, he sees the signal instantly and acts judiciously, and the danger is not great. The same is true of other accidents; such as a failure of the steering gear, a "man overboard," or an unexpected manœuver to avoid a vessel or other danger suddenly discovered ahead.

But suppose the officer on the bridge of the ship ahead is slow to act, or loses his head and does the wrong thing, and in addition to this, neglects to signal that anything is wrong. If now the officer on the bridge of the next astern is as alert as he should be, and as ready to recognize and to meet the situation, all will still be well; but if he is giving his attention to other things, perhaps studying the chart, perhaps making an entry in the log, perhaps engaged in something far less justifiable than these, he may lose the brief interval in which he has time to act, or may be forced to act so quickly that his judgment will be at fault,

and it may be his lot to become the responsible actor in an appalling tragedy.

It is perhaps essential that matters of internal routine should make some demand upon the attention of the officer of the deck at sea in squadron, but these demands should be reduced to a minimum, and should never for an instant cause him to forget the vastly more important demands connected with the safety of the ship. There should *at all times* be some responsible person on the bridge who is closely watching the movements of the ship ahead, and to this rule no exceptions should be made. If, therefore, the attention of the officer of the deck is for a brief time necessarily diverted to something else, he should caution his assistant to keep an eye upon the ships ahead.

It is well to prepare oneself for prompt action by frequently picturing the emergencies which may arise and settling upon the proper methods of meeting them. This habit, coupled with the vigilance which will result from recognition of the fact that the emergency, if it is to come, will come without warning and when least expected, will give the only assurance that is possible, of readiness to meet it with credit.

It is one of the unfortunate features of an officer's preparation for his duties, that very few emergencies can be simulated—with their attendant features of danger and surprise—for purposes of training. The situation, for example, in which a vessel suddenly looms up, from a dense fog, close aboard of one of the vessels of a battleship fleet, requiring instant decision as to the manœuver which will be best for keeping clear at once of the stranger and of the neighboring vessels of the fleet, is one in which no officer can hope for much practice, except in his own imagination. And so with many other situations.

Much is gained by making sure that all emergency arrangements are in working order, and that the men stationed to operate them are thoroughly acquainted with their duties; the breakdown flag rounded up to its place; the signal gun ready, with ammunition at hand; fireworks of any kind prescribed, in their appointed place; the life-boat ready for lowering, the crew mustered and inspected; men detailed to run aloft in case of man overboard, to keep him in sight and signal to the boat; a force detailed for shifting steering-gear in the event of a breakdown;

men at the engine-room telegraphs for regulating the speed; men at the cones or other speed-signals for communicating with the ships astern; the position-buoy ready for going over promptly if there is a possibility of fog, etc.

eeping lookouts up to their work, an officer should not em but should remember that he is his own best look- at if he sees danger first, he gains time which may be oiding it. This is especially important in a fog.

s even greater gain in reading signals for oneself trusting to signal-men who may be both stupid and And it is a good rule to verify all tactical signals by o the Signal Book or to a memorandum in which the rtant of the tactical signals are set down.

portant also to note whether neighboring ships have read the signal correctly and are starting out to per- ianœuver properly, as a mistake made by any one ship re dangerous to others than to herself.

y the officer and junior officer of the watch but the ter and helmsman also should know to which side the uired to haul out in case of breakdown.

cer of the deck should never enter the chart-room at pt in case of necessity. To do so, not only takes him a station which he ought never to leave, but makes eless for an appreciable time after he comes out. So g over the log or a chart—though the last may of essential.

portant to keep the engineer officer of the watch in- advance as to changes of speed in so far as these can , and to let him know how long a given condition will ontinue. If stopped or running slow this may save off." It will also enable him to prepare for keeping hen "standard" speed is again called for.

be remembered that the Rules of the Road do not essels running at night without lights. A fleet run- is way must therefore keep clear of all vessels carry

"Notes B"

Handling Ships

Official Rules Prescribed for Atlantic Fleet (1921)

1. **Maintain position.** This requires constant attention and alertness.

2. **Regain station quickly.** During maneuvers, if a ship loses her position she must regain it quickly. This requires radical changes of revolutions and course.

3. Until ships are in correct position, the next maneuver, as a rule, cannot be performed.

4. When cruising, work with small changes of revolutions.

5. **Guide.** The **Guide** must exactly maintain the prescribed speed and steer a steady course.

6. **Uniform steaming.** Uniform steaming of Fleet Units is demanded under all circumstances, both for cruising and for the line of battle.

7. **Do not be astern of your station when in column.**

8. **Do not be ahead of your station when in line of bearing.**

9. **Change speed with directing ship.** When in column, and speed is changed by signal or otherwise, make the change with the directing ship. Do not wait to follow the movements of some dilatory ship that may be ahead of you.

10. **Check revolutions.** When in formation, the revolutions should be checked by revolution indicators on the bridge at least every ten minutes.

11. **Steering.** Good steering is essential alike for station keeping and for accurate "Dead Reckoning."

12. **Train your eye.** Train your eye to judge distance. Do not be wholly dependent upon rangefinders and speed indicators.

13. **Watch "coming on."** Alertness on the part of the officer-of-the-deck will prevent the watch "coming on" causing the ship to lose position. New steersmen and new hands at the throttle require supervision.

14. **You may be the one in error.** The ship ahead is always wrong and the ship astern nearly always so. Notwithstanding this condition, it is entirely possible with skillful handling of your own ship to hold your correct position in formation. If other ships are handled badly, the greater will be the opportunity to train the officer-of-the-deck of your own ship. Do not blame other ships, but keep your own in position, regardless of difficulties created by others.

15. **Responsibility for safe navigation.** It should invariably be thoroughly understood in every ship, whether she is in company with a fleet or detached, that her own officers are always responsible for her safe navigation. Therefore, when in column in cramped waters, do not blindly follow your leader under the supposition that, because he may have safely passed foul ground ahead, you, perhaps some distance astern, are bound to do the same. There is generally either tide, set, or wind, to consider, and it is sometimes remarkable how much the end of a long line of ships may be deflected from its proper course by one or a combination of these.

16. This applies when entering or leaving a harbor, or passing through the entrance of a breakwater:—**look out for your own navigation.**

17. **Rules of the road.** The "Rules of the Road" govern all movements, and nothing justifies a ship getting to her position (however smartly) at the risk of her safety or another's.

18. **Speed on dispatch duty.** It is well known (and provided judgment is also present) that the faster the ship is moving through the water the easier she is to handle. Therefore, when at work on any detached duty amongst the fleet, till that duty is completed, use the engines with the cones right up, giving plenty of rudder, and you cannot go far wrong; but remember the rule, "Never let your boat go faster than your brain."

19. **Turn sharply.** When leaving a formation, ships should turn out sharply, when practicable, so as to render the intent quickly apparent.

20. **Rule for handling ship while lowering or picking up boat.** When not in contracted waters and you are obliged to stop to lower a boat or have a boat come alongside, do not keep your engines backing so long that the back water works forward of the davits or gangway (as the case may be). A little headway will do no harm—and you may back again later, if necessary. It is confusing to a coxwain to suddenly find himself in a contrary current, and more so to the coxwain not specially skilled.

21. **Obeying signals in flagship.** A signal of execution in a flagship should always be immediately obeyed in that ship.

22. **Do not follow ship making error.** Ships should not follow, or be guided by, the motions of ships which clearly misinterpret a signal.

23. **Getting underway, heave in together.** Upon the execution of a "get underway" signal, ships should heave in and get their anchors as quickly as possible. All ships should be riding to the prescribed scope of chain when the signal is executed.

24. It is more important to get underway promptly than to moor with rapidity.

25. **Speed of windlass.** The anchor windlass, when heaving in, should always be run at its designed speed.

26. **Use engines to ease strain on chain.** If there is a strain on the chain when the "get underway" signal is hoisted, the main engines should be used to slacken the chain so that there will be no delay in heaving in.

27. **Keep pointed.** When a ship is "away," she should only use her engines sufficiently to keep her head pointed in the direction it was before the anchor was tripped, unless a casting, course, or formation signal has been executed.

28. **Getting underway.** When signal is made to cast to starboard (or to port), ships, while casting, must:

(a) Adhere rigorously to the anchorage line of bearing;

(b) Maintain their bearing from the guide;

(c) Turn **with** the guide—not before nor after—to the prescribed heading;

(d) Be ready to take standard speed with the guide; and,

(e) Be ready to promptly perform the next evolution.

29. **Turning on your heel.** To turn a ship on her heel and at the same time preserve exact bearing and distance:

(a) Go full speed astern with the propeller on the side on which you require her head to come up;

(b) The instant she begins to move, go full speed ahead with the propeller on the other side;

(c) Keep the inner propeller at full speed astern the whole time and work the other engine against it as may be necessary.

(d) Do not forget to stop both engines in time to steady on the desired heading.

30. **Take station passing column.** Having no way upon your ship, to take up your station in a passing column you should go ahead one-third speed when your "next ahead" is about twenty degrees abaft your beam; take the guide's speed when your "next ahead" is abeam.

31. **Watch shore ranges.** When getting underway and when anchoring, watch shore ranges, if practicable, to determine what your ship is doing over the bottom.

32. **Exchanging stations.** When exchanging stations in column be careful not to edge in too close to the bow of what will be your next astern.

33. **Forming column from line of bearing.** A ship forming column on a guide from a bow, beam or quarter bearing, must conform, more or less, with the rudder and speed of the ship next towards the guide.

34. **When scattered use full speed to form.** If the ships are scattered and signal is made to form, individual ships should steam at full speed and take station as quickly as possible.

35. **Tactical diameter when forming.** When standing down to take station in a column, keep your ship just outside your tactical diameter from the column. You cannot foul the column if your rudder is hard over, although by bad judgment you may turn up short or otherwise. Steam at full speed.

36. **Do not edge in.** Never drop in to your position in a fleet underway by slowing down and edging in. Much time is lost thereby and it is a lubberly performance.

37. **Come in on stern of next ahead.** When taking up your position in a column be careful as you close in to note the course of the column in comparison with your own heading. Come in on the stern of your next ahead and, providing you are going fast enough, you cannot interfere with your next astern, which is always the danger.

38. **Joining from ahead.** When taking up your position in column from ahead, you can always roughly estimate the course of the column by the relative angle of the masts; if they are in line, you know at once. This done, come swinging down on the opposite course, and remember that when you put the rudder over for the last turn, the ship you are forming on is moving ahead the whole time.

39. **Communicating by boat.** When closing in to communicate with another vessel which is stopped, nothing looks better to others, or is more satisfactory to yourself, than that your ship should be nicely stopped at the right place—which means that the boat which you are lowering should have as short a pull as possible. But you must always bear in mind that the bow of your ship must be inclined out from the side of the other, and also remember how big masses in water attract each other and suck together; and that the other ship is making something good to leeward.

40. **Going alongside dock.** On running up alongside a ship, and the same applies to going alongside a dock, as you draw up to the vessel ahead (till you are accustomed to it) you are likely to be deceived as to the distance you will be off when you arrive abreast, and you will find that you are nearly always much closer than you expected.

41. **Line of bearing.** By remembering the following points, the usual difficulties encountered by the beginner, when steaming in line of bearing, may be readily overcome.

42. The bearing must continually be verified and, if necessary, be at once corrected by increasing or decreasing speed.

43. **When your bearing is correct, remember that:**

(a) The distance may be changed by altering course slightly (2°, 4°, 6°) and changing your speed.

(b) A change of course away from the advanced flank (i.e., towards the normal to the line of bearing) will cause the ship to forge ahead rapidly if the speed is not immediately reduced.

(c) Small changes of speed are generally not sufficient to prevent a ship getting ahead of her proper bearing when she alters her course away from the advanced flank. A change of course of but 3 degrees away from the advanced flank will, as a rule, demand a speed less than standard.

(d) A change of course towards the advanced flank will cause the ship to drop back, if the speed is not increased simultaneously.

44. **When both distance and bearing are incorrect:**

(a) Increase speed and change course, if abaft the bearing.

(b) Decrease or maintain speed (according to the amount that the course has been changed at the same time) if materially ahead of the bearing.

45. If the distance is correct and you are ahead of the proper bearing, a reduction of speed without altering course will increase your distance. Therefore, when you are ahead of your bearing, in addition to reducing speed, simultaneously change course towards the advanced flank.

46. If ahead of your bearing, and your distance is so little that when you drop back it becomes necessary to change course away from the advanced flank, a rapid regaining of the correct bearing is possible only by a considerable reduction of speed.

47. If abaft your bearing and your distance is either correct or too little, an increase of speed only will bring you on the bearing but will further reduce your distance. You must, therefore, in addition to increasing speed, change course slightly away from the advanced flank, but be careful to avoid forging ahead of the proper bearing.

48. If abaft your bearing and your distance is too great, you must change course somewhat towards the advanced flank and then you may energetically increase your speed.

49. **Bearing Rule.** In general, stick to the rule, **"Keeping correct bearing must be rated higher than keeping correct distance; and above all, you must never forge ahead of the line."**

50. When ordered to take up position astern of any ship at equal speed from any bearing except direct ahead, you will arrive in her wake at approximately the same distance from her as when you started, if, when the signal is hauled down, you take the bearing of her foremast and steer that course.

51. **Column.** In changes of direction by column movement, the following points must be observed:

52. The formation must be accurately maintained.

53. The masts of each ship, immediately upon completing the prescribed change of course, should be on the proper line of bearing from the column leader.

54. Each ship should be at proper distance immediately before and immediately after the prescribed change of course has been made. Never be appreciably too close when your next ahead reaches the turn. In order to avoid this, speed must be reduced, if necessary, when the evolution signal is hoisted, but remember that every reduction of speed causes some disturbance to ships astern. In large turns especially (90° to 180°) too little distance is uncomfortable and likely to result in your turning outside.

55. If you reduce speed before turning, because too close, then when beginning to turn or very soon thereafter, resume standard speed; otherwise, you will be sure to drop behind. In some circumstances even an increase of speed will be necessary.

56. **Fault to Turn Late.** It is an ugly fault to start a turn so late that even full rudder cannot prevent your ship over-running the correct bearing from the column leader.

57. **Result of Late Turn.** By making a turn too late, a ship increases the turning arc established by the column leader and this impedes correct turning by ships following, besides making the column ragged.

58. **Stern.** The stern of a ship while turning deviates outboard from the original track.

59. **Steady Compass Course.** Each ship should keep a steady compass course up to the turning point. If no suitable objects for the steersman are available ahead, and it is not possible to depend sufficiently upon the steering compass, look astern in order to detect at once any turning of the ship by the swinging of the stern to the right or left from the rest of the column following.

60. **Chasing Tails.** It is improper to maintain heading on the stern of your next ahead while the latter is making the turn.

61. The resulting effect of a ship chasing tails is to increase the tendency of following ships to sag away, thus making it almost impossible for them to turn correctly.

62. The marked swinging out of the stern of the ship ahead makes at first a rather alarming impression at the normal distance with the modern long ships. It takes some time before the stern begins to return again to the tangent; and, as your own ship, on account of the loss of speed of the ship ahead, will at first run up on her, you are likely to think that there is danger of collision. In reality, such is not the case if your ship is properly in station. Your ship, it is true, will approach rather near to the stern of the ship ahead, but as soon as you begin turning, the distance will be opened again by your own loss of speed and the taking up of speed by your next ahead.

63. **Turning Point.** Begin turning at exactly the same point as the column leader and not at the turning point of your next ahead if he turns short or outside.

64. **Wake Rule on Turn.** If your next ahead has turned properly keep your stem inside the rough water of his wake. The distance inside should be approximately equal to the beam of your ship.

65. **Early vs. Late Turn.** Better begin turning too soon than too late. Turning too soon may be easily rectified by easing the rudder and, if necessary, reducing the speed. When, for any reason, the rudder was moved too late, at once apply a larger angle and increase the speed, because otherwise you

will always drop behind. During the course of turning, notably during its last part, the observing of the angle between the column already formed on the new course and the midship line from the conning station to the stem, will furnish a good clue to determine whether the ship, with the rudder kept as it is, will still come around in time or not.

66. **Do Not Repeat Errors of Ship Ahead.** When the ship ahead, by faulty turning, goes outside the arc of turning of the column leader, take your direction from the column leader. If necessary, increase the amount of rudder in order not to come too close to the ship ahead. In turns up to 90 degrees in such a case, you may, without fear, head at first for the middle or even the bow of your next ahead. If need be, there always remain the stopping of the inboard engine and a reduction of speed. When the fault of the ship ahead is great, you will, in most cases, range alongside of her at a pretty close distance.

67. **Hold Your Course.** While your next ahead, having turned outside, returns to his station, the distance between his inner quarter and your bow may be a little close. You must not ease your rudder, if you are in station. Reduce speed, if necessary, but when doing so do not forget your next astern.

68. **Increase Speed While Edging In.** The ship edging into the column must increase her speed while so doing.

69. **Get Turn in Hand.** Upon all occasions, when turning in column, endeavor to get the turn well in hand. If your ship is inclined to turn short, the rudder can always be eased; but, if the turn is made too late, the rudder has to be put hard over and once it is there no more can be done.

70. **Start Turn Promptly.** A ship must **start** her turn promptly even though it requires a hard over rudder to do so.

71. **Check Bearing in Column.** As a guide leading a division through a tideway, perhaps it is safer to put the ships of the column on a bearing from the guide, instead of allowing them to attempt to follow round in the wake of the next ahead; but, in all cases, every ship in the column should endeavor to pass over the same ground.

72. **Fog.** Do not drop astern of your station while in a fog.

73. **Correct Errors on Turn.** When making a simultaneous turn from column to line or to line of bearing, and vice-versa, check your distance from the guide and from the next ship towards the guide. Correct errors in distance during the turn.

74. **Turn Rules.** In simultaneous turns, ships must:

(a) Start the turn promptly when the signal is executed;

(b) Regulate their speed and rudder angle so that they will be in station when they have swung to the prescribed heading;

(c) Remember that a change of the prescribed rudder angle generally necessitates a change of speed;

(d) Watch carefully their next towards the guide;

(e) Follow standard procedure for easing the rudder and meeting her;

(f) Not swing beyond the new heading.

75. **Standard Speed and Rudder.** The practice of rigorously adhering to the standard rudder and never changing the speed of the engines by signal from the bridge while turning is not correct. Standard rudder and standard speed is only a general rule and must be departed from as occasion requires.

76. **Approaching Anchorage. Radical Speed Changes.** When approaching an anchorage, or at any other time in formation, when the speed is much reduced and the ship is out of position, it should not be attempted to regain position by a small change of revolutions. The change should be radical for a short period of time, in order that the ship regain her station quickly. Remember that the speed of the ship is not, necessarily, equivalent to the speed of the engines. Considerable time is required to overcome the momentum of a heavy ship. When a ship is at rest, or nearly so, slow speed for regaining position is of little more value than getting out an oar. To produce results quickly, the engines must be worked with considerable power.

77. **Backing without Swinging.** When it is intended to back the engines while the ship is going ahead, if there is time, the ship should be first going steadily on her course, with rudder amidships. If the ship is swinging at all, she will swing more violently in the same direction as soon as the engines are backed and the only way that this swing can be checked is by going ahead full speed on both engines with the rudder hard over, and as soon as the bow starts swinging in the other direction, reverse the engines and the ship will come back to her course. The handling of the ship under such conditions must be prompt.

78. **Swinging Stern.** When anchoring in succession or when approaching another ship, and it is desired that the ship's stern shall swing in a particular direction, the swing must be started before engines are backed. The ship may be relied upon to continue that swing after the engines start backing.

79. **Anchoring Backing Power.** When anchoring in formation, as well as when approaching an anchorage in a crowded harbor, or the vicinity of other ships, a ship should maintain plenty of steam pressure, in order to have ample backing power to control the ship in case of emergency.

80. **Never Snub Chain.** In anchoring, a ship should never be snubbed by the chain. The momentum of such a heavy weight is great even at low speed and may be relied upon as sufficient to part or weaken the chain. Chain should be veered until way is lost then hove in as necessary.

81. **Approach Anchorage Boldly.** When anchorage water is clear, ships, whether in formation or not, should approach the anchorage boldly. Nothing looks worse, or is more indicative of timidity and lack of self-confidence on the part of the Commanding Officer, than to drift up to the anchorage, under barely steerageway, with a ship or ships which handle quickly, thereby losing control of the ship as well as position in formation.

82. **Let Go Anchor with Execution Signal.** All ships should anchor simultaneously the instant the anchorage signal is executed. It is unfair to your next astern if you "hang on" to make up lost distance and he has properly obeyed the signal.

83. **To Moor.** To moor in a harbor:

(a) Steady your ship on the anchorage bearing;

(b) Then devote your attention to letting go the first anchor;

(c) Do not snub the chain, but have plenty of way on and let the chain lay itself out straight;

(d) Endeavor to have the ship at rest just after the second anchor has been let go;

(e) Then go full speed astern, keeping in mind your next astern.

CHAPTER XXV

TOWING.

§ I. The TOW-LINE.

Generally speaking, the longer and heavier the tow-line used, the easier the towing will be. A decided dip or "catenary" gives the same advantage here as in the case of a vessel riding at anchor with a good scope of chain;—that is to say, the sagging bight acts as an elastic spring, preventing variations in the tension from being thrown upon the line in sudden jerks; and the sag of the bight depends not only on its length but on its weight.[1] Unfortunately, however, too great weight is a serious inconvenience in handling and running lines. This is the principal objection to chain-cable, which in many ways is an ideal tow-line. Another objection is that if the vessels are obliged to stop, the weight of the chain may prove sufficient to drag them into collision. In the excellent work on Seamanship by Captains Todd and Whall, the use of chain-cable (alone) is recommended for all cases of heavy towing; one of the authors testifying to its availability as the result of his own experience upon several occasions. This is high authority, but the present author has collected the views of more than forty prominent shipmasters, every one of whom says that under no circumstances would he attempt to tow by chain alone, unless compelled to do so.

Wire-rope is very convenient for handling, and makes an excellent tow-line for smooth water, but is much too light to give a satisfactory spring for all-around work under ordinary conditions. All of its advantages may be realized and its disadvantages eliminated, by the use of a *Towing Engine*, which sub-

[1] Observe that the dip does not in the least reduce the tension of steady towing. What it does is to furnish an elastic link between the ships, by which the forces already described as arising in a seaway are absorbed gradually instead of being thrown upon the line with the suddenness and disastrous effect of "impact."

stitutes the elasticity of steam pressure for that due to a long and heavy line. This will be referred to at greater length hereafter.

Both chain and wire have a serious disadvantage in that they are not buoyant, as are lines made from vegetable fiber.

Manila, while heavy enough to give a good dip if used in sufficient length, is not too heavy for convenient handling and its buoyancy is a great advantage, particularly where lines are to be run by boats or hauled across over considerable distances. It is, upon the whole, the most satisfactory line that can be used for moderate towing; but although heavier than wire of corresponding strength, it is still much too light for towing in a seaway. Its weight is increased in some cases by hanging a good sized kedge to the bight between the two ships;—a device which is evidently available with wire, as well as with manila. A more common plan is to use a combination of chain-cable with a manila or wire hawser, or both, the hawser being made fast to the towing ship and the chain-cable paid out by the tow.

When the conditions for getting the lines across from one ship to the other are fairly good, a combination of wire and chain is perhaps the best; but in bad weather, or when, for any reason, the ships cannot come close together for running the lines, the buoyancy of manila—its "floatability"—shows up as an enormous advantage, especially where the vessel which is to receive the line, get it on board, and secure it, is a small craft, such as a destroyer. The use of a manila hauling line helps out, but cannot do away with the difficulties connected with dragging a wire-line across a long stretch of water and securing it on the cramped forecastle of a small vessel which is perhaps plunging into a heavy sea. A good plan is to combine manila and wire, the towing vessel first paying out the manila line, which is hauled across by the tow and secured, after which the towing ship shackles the wire-line to the manila and starts ahead very slowly, paying out the wire-line as she gathers way.

For towing even a vessel as small as a destroyer in rough weather—and it must not be forgotten that rough weather may be encountered in almost any towing expedition—the full length

of an 8-inch manila line with the added length of a 5-inch or 6-inch wire, will be none too much.

Where the tow is able to haul across and handle a wire-line, and especially where she proposes to use with it a good length of her own bower-cable, a 6-inch or 7-inch wire-line is recommended. The length that is needed will vary with circumstances, but it is far better to have too much than too little; and the use of a margin of safety which seems unreasonably large may result in a very comfortable security from the vexatious accidents and delays which are so common in towing.

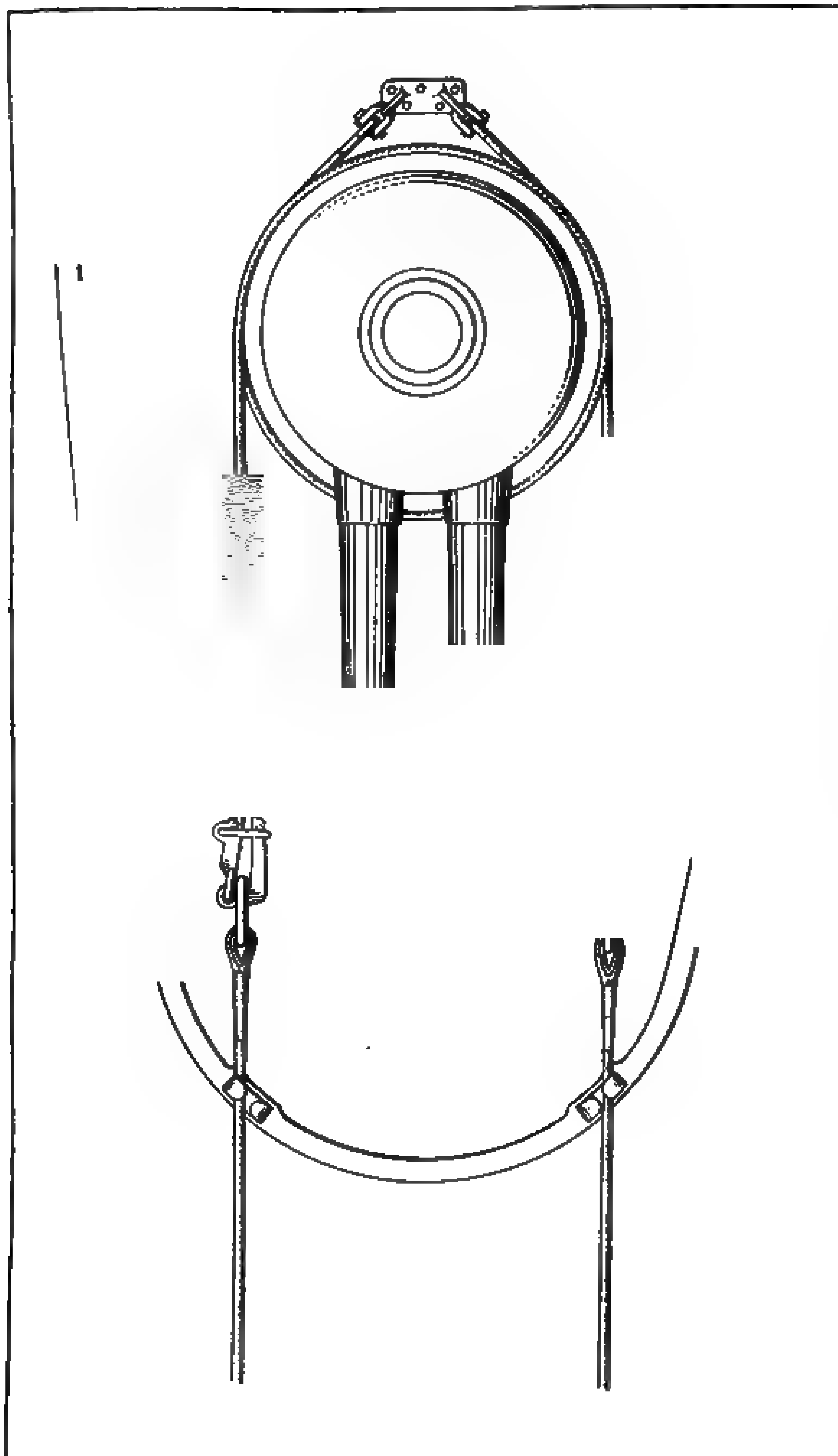
Where a battleship is to be towed, the full length of a special 7-inch wire-line (200 fathoms) is recommended, in addition to 75 or 90 fathoms of bower-cable. With such a line there should be no troublesome break-downs *unless the speed is forced unduly.* (See remarks below on "*Speed and Resistance.*")

Securing on the Towing Ship. In securing the line, consideration must be given to the possible necessity for letting go in a hurry. It is clear that there are many emergencies which may arise in which the line must be gotten rid of in the shortest possible time; such as a sudden threat of collision. This is a point which is not always given the consideration to which its importance entitles it.

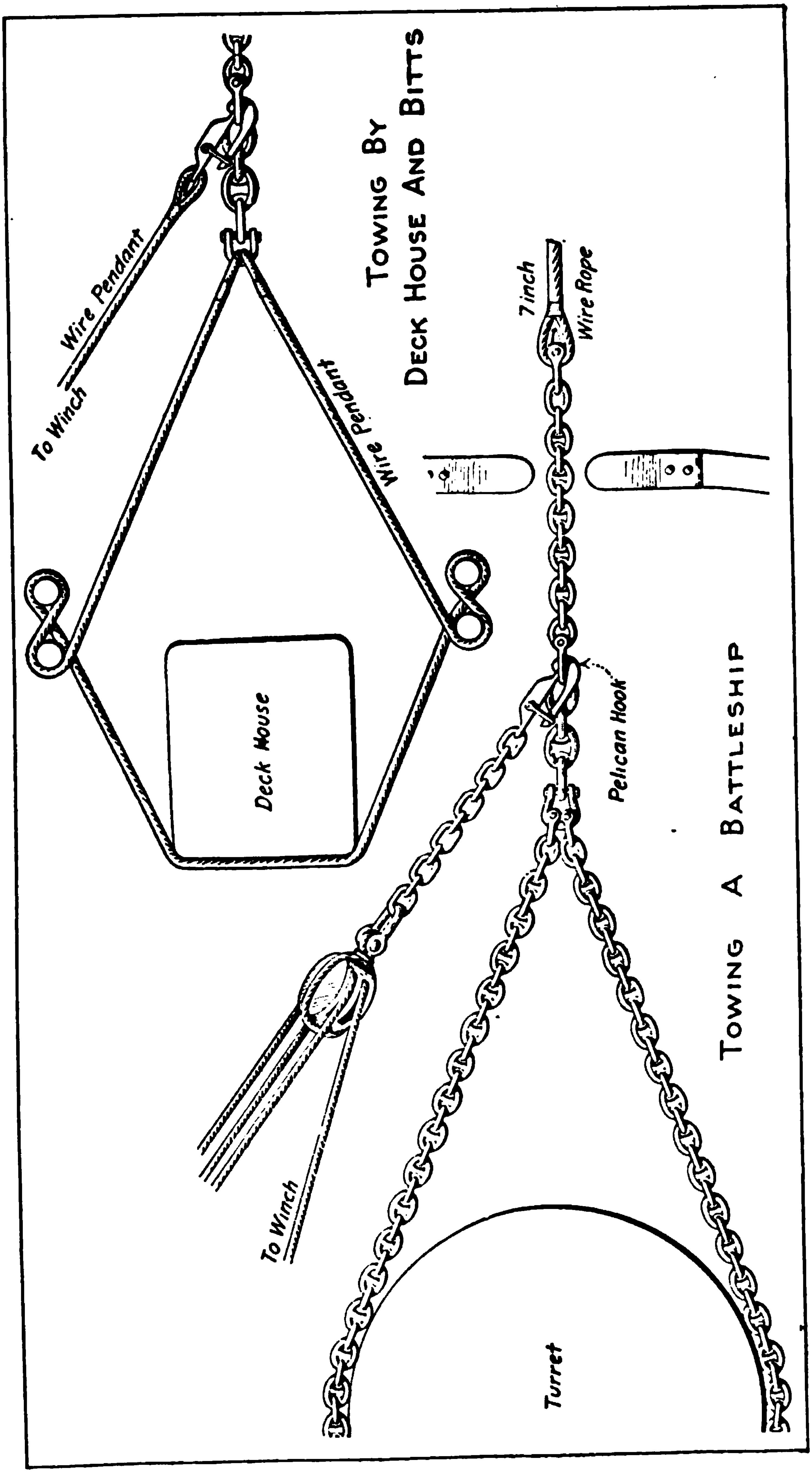
For convenience in letting go, it is desirable to have a break in the line near the stern; that is to say, to have, at or near this point, a shackle connecting two parts of the line, together with some arrangement, like a pelican-hook, for slipping quickly.

The objection to letting go at any point well inboard of the ship is that a dangerous "whip" is certain to result as the end of the line goes out.

To have the end only just inside the stern-chock on the towing ship means that practically the whole length of the tow-line must be paid out, and that any variation in length must be taken care of by the tow. As it happens, this is usually the simplest way to arrange matters, provided the bower cable of the tow is in use as a part of the line, as it almost always is. It is very easy to heave in or veer away on this, as may be necessary for shortening or lengthening the line.



TOWING A BATTLESHIP.
(BRITISH NAVY)


Towing By
Deck House And Bitts
To Winch
Wire Pendant
Wire Pendant
Deck House
7 inch
Wire Rope
Pelican Hook
To Winch
Turret
Towing A Battleship

TOWING.

A point of some importance in towing in a seaway is to keep the ships "in step" as nearly as may be; that is, to use such a length of line that they shall meet the waves and ride over them together. If the length of the line is such that one vessel is in the trough of the sea as the other is on the crest, the line will for a moment slacken, then tauten out with a sudden jerk; whereas if they meet the waves at the same time the tension on the line will remain comparatively steady. The wave-lengths of a sea are usually approximately uniform at any given time, and it should not be difficult to arrange the line as above described by heaving in or veering away the cable on the tow. In towing for a long time and covering a great distance, extreme variations may of course be found in wave-lengths, and the inconvenience of changing the length of the line from time to time may more than offset the advantage to be gained; but it is worth while to recognize this point and to be ready to take advantage of it when circumstances permit.

If the towing ship has a chock at the stern and amidships or nearly so, the line should be brought in through this. It is a good plan to use a short length of chain for the lead through the chock, shackling outside to an eye in the end of the wire-line, and inside to a pendant or span from the turret, the bitts, or elsewhere, according to the arrangement decided upon for securing. The chain through the chock not only takes the chafe—under which the wire would cut through—but by its flexibility does away with the dangerous "nip" which would be thrown into the wire if the tow chanced to take a rank sheer off onto the quarter.

If it is thought that the chain may suffer from chafe, a perfectly efficient sleeve may be made by wrapping it with a sheet of copper from 1/8 to 1/4-inch thick.

If chain is not to be used for taking the chafe in the chock, the tow-line must be very carefully protected by chafing-gear, which it is well to put on in the shape of a long and bulky "pudding." The stiffness of such a pudding reduces the sharpness of the nip which without it would be thrown upon the wire from time to time by the sheering of the ships.

The arrangements for securing the line inboard *on the towing ship* will vary widely with conditions.

In men-of-war, a pendant of wire or chain is sometimes taken around the after turret, as in Plates **172** and **173.** The first of these plates shows the method used in the British Navy where one battleship tows another. Two lines are used here—a plan which has some advantages and a good many disadvantages. The

second plate shows what is considered to be upon the whole the best arrangement for heavy towing. A wire pendant may of course be used around the turret, instead of the chain here shown.

In a ship having no turret, the pendant may be taken around a deck-house, with a few turns around the bitts on each side, as in Plate **173**.

Where the strain is not too heavy to be taken by the bitts, the arrangement will be that shown in Plate **174**, the line being taken around as many sets of bitts as are available. To divide the strain here, it is advisable to take only one or two turns around the first bitts, thus leaving the line free to "render" slightly and so transfer a portion of the strain.

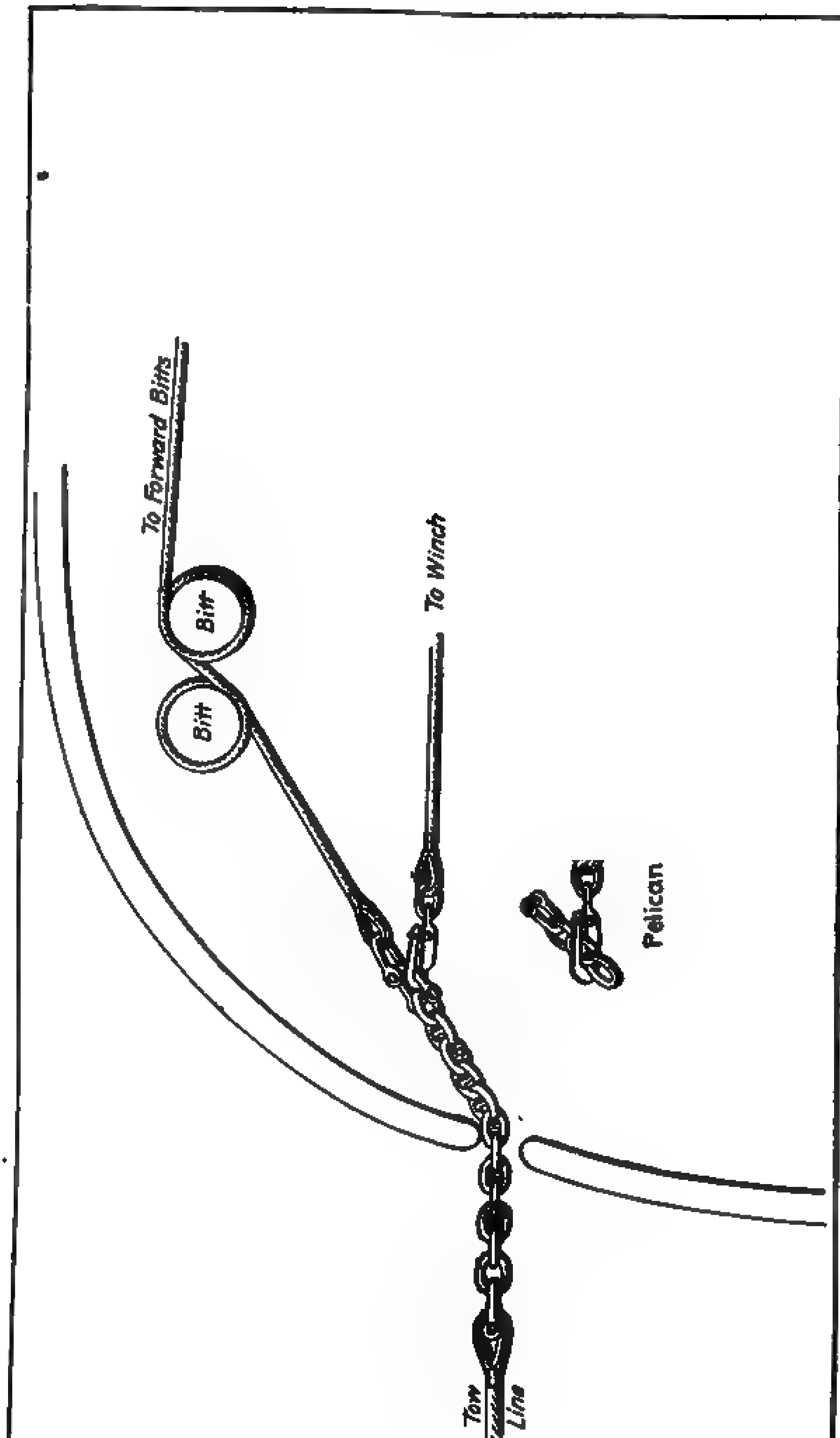
In all of the arrangements shown in the plates, pelican-hooks are used for letting go. In the case illustrated in Plate **172**, the hook has the weight of the tow at all times.

In the other cases, the strain is taken momentarily on the hook, relieving the shackle and admitting of knocking out the shackle-pin, after which the pelican-hook is slipped. This arrangement entails a little delay, which, however, need not exceed a few seconds, and the whole arrangement is more secure than that of Plate **172**.

If it is not convenient to use an extra shackle for the pelican-hook, the hook may be used directly on the chain, as in Fig. 2, Plate **174**.

If no pelican-hook is at hand, a strap may be used on the chain or wire, outside of the shackle, and a heavy purchase hooked to this and taken to the winch. For letting go, the strain is taken by the winch long enough to disconnect at the shackle, after which the strap is *cut*. (Fig. 3, Plate **174**.)

There are some conditions under which it is convenient to use a *span* on the towing ship, the two parts being brought in through the quarter-chocks. Generally speaking, this makes it rather easier for the towing ship to steer and the advantage gained in this respect may become important in cases where a small ship is dealing with a heavy tow. Where the line leads from a chock directly over the rudder, it binds the stern so that it can only swing in obedience to the helm, by dragging the tow with it. A large ship can take care of this situation by the power of her steering gear, assisted, if necessary, by the screws; but a small ship with a heavy tow and with the line leading through the



Towing By Bitts.

Towing a Vessel with a Manilla Hawser Bent to Bower Cable.
(Anchor Shackle)

SECURING TOW-LINES.

stern chock, if she steers at all will be very sluggish. Tugs which are specially fitted for towing have their bitts well forward of the rudder, allowing a chance for the stern to swing; the fittings abaft the bitts being such as to let the line sweep freely across from one quarter to the other.

Where a span is used it may be of chain, wire or manila, chain being probably the best. In this, as in other cases, arrangements must be made for letting go quickly if necessary.

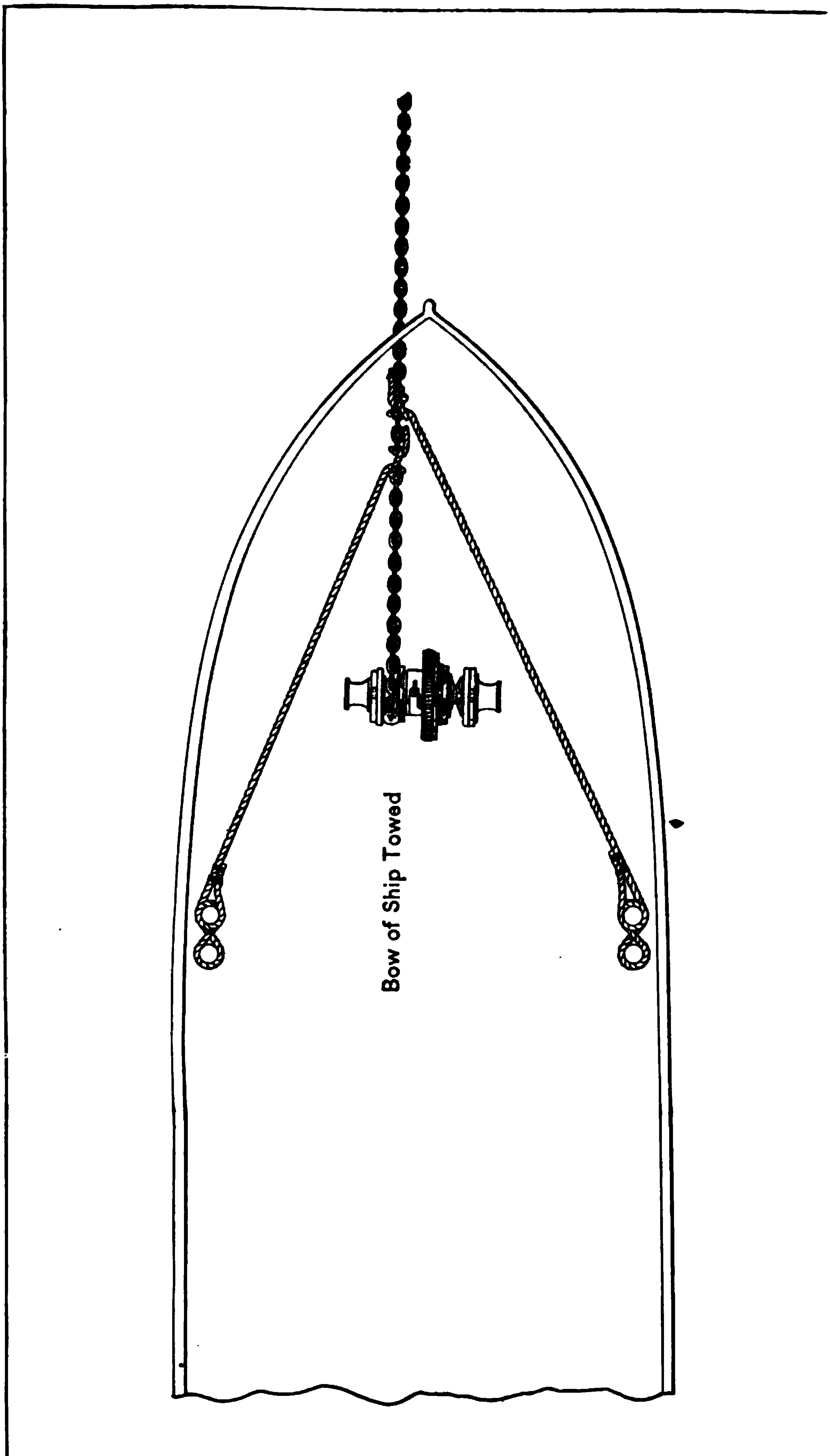
Where chain is used for the span, two lengths of bower-cable are gotten aft, one on each side, and passed through the quarter-chocks. The outer ends are then brought in over the rail and connected together by an anchor shackle, to which the end of the towing hawser or chain is also made fast (Plate **175**). A bull-rope is made fast to the shackle, for lowering the span over the stern after the lines have been secured and for heaving the span up to the rail if the line parts or if it is desired to let go.

The details of securing the lines inboard must of course depend upon circumstances, but it is important to distribute the strain over as many sets of bitts as possible.

A convenient plan is to bring the tow-line in through the quarter-pipe on one side and bend a hawser to it from the other quarter-pipe at such a point outside that the two parts shall form a span of convenient length. The lines may be made fast around the bitts and to the mast or a deck house in practically the same way as in the methods already described. This plan has the advantage that by letting go the second line we get rid of the span at once and have to deal only with the tow-line itself.

On board the tow, the hawser is usually bent to the bower-cable (Plates **175, 176**), although there may of course be many conditions under which some other arrangement will be necessary. If the cable cannot be used, it is desirable to use at least a short length of chain to take the chafe in the chock in the same manner as already described for securing on the towing ship. If even this is impracticable, abundant chafing-gear must be used, and this should be examined several times a day and renewed as often as may be necessary.

Where the bower cable is used, the line is bent or shackled to it and the cable veered away to the desired length, after which the windlass brakes are set up and springs, to take the real strain of towing, are put on as in Plate **176**. It is well to have a shackle



SECURING LINES IN TOWING.

between the windlass and the point to which the springs are bent and to keep tools at hand for unshackling if it becomes necessary to let go in a hurry. Generally speaking, however, the tow should not let go in this way except in case of extreme emergency, as the line, weighted with a considerable length of heavy chain, would sink immediately, hanging as a dead-weight from the stern of the towing vessel, where it would be extremely difficult to handle and would be in danger of fouling the screws. This applies only to cases where the tow is a vessel of some size, and where she is towing by her bower cables. It is evident that where a large ship is towing a small one, the natural way of casting off is for the tow to let go, leaving the line to be handled by the large ship. There is here, however, no question of a heavy chain-cable hanging from the end of the line.

In the more general case where the bower-cable of the tow is in use, the natural way to let go is for the tow to heave in her cable and then cast off the line.

There may, of course, be cases where the towing vessel is the proper one to let go, leaving the tow to handle the whole of the line. And cases may arise in which both vessels must let go, sacrificing the line to avoid some serious danger.

> NOTE.—It is well to remember that in an emergency the towing vessel may safely back her engines without letting go the line and without danger of fouling the screws; but this must not be continued long enough to check her headway altogether—much less to let her gather stern-board—as to do this would involve danger not only of getting the line into the screws, but of being rammed by the tow. *On the tow, the helmsman should always be alert and ready to sheer out in case of ranging up onto the towing vessel.*

A plan which has many advantages for securing the line on the tow, is to bend it to the crown of the anchor and let the anchor go, veering chain to the proper length. Not only does this save the time required for unshackling, but it leaves the anchor on the bight of the line, where it should be very helpful in the matter of "dip." If the strap shown in Plate **110** is at hand, it will be very convenient here.

Naturally, this plan would not work in shallow water, as the anchor would take on the bottom.

Attention has been called to the difficulties connected with handling lines on the cramped forecastle of a small craft like a destroyer. Another point to be noted here is that the bower-cables of these small craft are not well suited for use as a part of the tow-line, and even if they were otherwise adapted to the work the difficulty in letting them go for casting off in a hurry—especially in bad weather—would be an insuperable objection to their use. A plan for securing the lines on vessels of this type is shown in Plate 177. Here a wire pendant is passed around the conning-tower and to this is shackled a pelican-hook which engages a length of chain sufficient to pass through the "bull-nose" and leave a little drift outside.

The pelican-hook should be large and heavy, as it takes the full weight of the tow. It must be fitted with a lanyard leading to the bridge, by which it can be tripped without sending anyone onto the forecastle. To the end of the chain is shackled a pendant of wire-rope long enough to lead aft, outside of all, to the bridge or some other point at which it is convenient to handle lines even in bad weather.

The line from the towing ship, which is preferably of manila for reasons already explained, is hauled over to this point of the tow and shackled to the wire pendant, after which the bight is let go, giving a clear lead.

For casting off, it is only necessary to trip the pelican-hook.

Where time permits, it is very desirable to prepare for towing operations by splicing eyes, with heavy thimbles, into all lines which are to be used, and providing shackles for connecting up at all points, thus doing away with the necessity for using bends and hitches, which weaken manila very seriously and are fatal to the efficiency of wire. At least two short lengths of good chain should be provided for the leads through the chocks on both the towing ship and the tow, and it will not be amiss to have two or three other lengths of, say, a fathom each, for use at any point where they may be wanted. Two or three wire pendants with a thimble eye at each end will be needed also. The plates illustrating this chapter will make it clear where these various parts are needed.

The pelican-hooks should be so heavy as to give a very large margin of safety. This is especially important where the stress

of towing comes continuously on the hook. The link which engages the hook should be long enough to let the tongue of the hook slip freely through on letting go and if the chain which is to be used is not fitted with an end link of this character, a shackle should be used. This is often the most convenient plan, and it illustrates the importance of keeping on hand a number of spare shackles for general utility. Such shackles are preferably larger and more open than those commonly used with chain-cables.

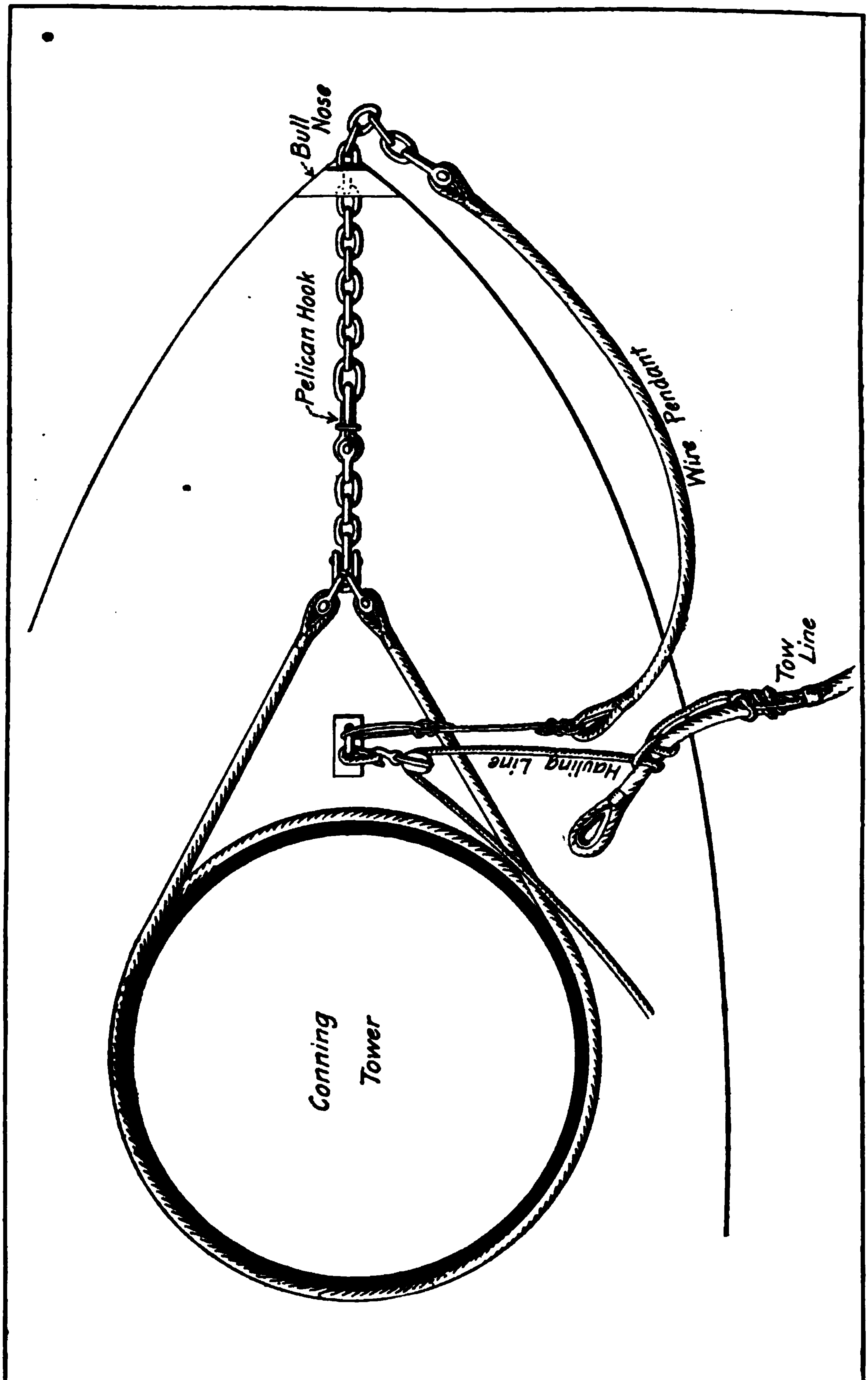
It should be remembered that the stud may be knocked out of a link to admit of using it with a shackle, without weakening the link.

For getting the line across, in good weather, any one of a number of methods will answer. It may be run with a boat, a good length of the line being coiled in the stern-sheets and the remainder paid out as the boat pulls away. The towing ship is usually the one to send the line and should place herself, for this purpose, to windward of the tow. This not only gives the boat an easy pull to leeward, but makes a lee for her to work in. If the ships can come close enough together to admit of heaving the line across, this is of course a convenient method. For this, it is well for the tow to come up under the lee quarter of the other ship, being careful not to range up alongside far enough to let her stem overlap the stern of the other vessel. So long as her *stern* is well clear, she is free to sheer out and haul off if she finds herself getting too close or if the other vessel seems to be drifting down upon her.

If the vessels are practically abeam of each other and too close for comfort, neither one can haul off because to do so means that she must throw her stern in toward the other vessel.

For getting the line across under these conditions, it is well to begin with a light fish-line, weighted at the end with a piece of lead or iron of convenient size to fit comfortably in the hand and to admit of a long throw. The line is flaked down on deck, clear for running, and the weight is thrown like a baseball. It is possible to cover in this way several times the space that can be covered by the usual "heaving" line. The heavier lines are of course hauled across later.

Other methods, especially applicable to bad-weather conditions, are described below (§ III).



SECURING LINES ON SMALL CRAFT.

§ II. SPEED AND RESISTANCE.

In smooth water, the tension on the tow-line will be constant, after the inertia is overcome, so long as the speed does not vary. The following table gives the approximate values of this tension for ships of various sizes when towed at speeds from 2 to 8 knots.

APPROXIMATE TOW-ROPE RESISTANCES FOR SMOOTH WATER.

Displacement of Vessels towed.	Speed.			
Tons.	2 knots.	4 knots.	6 knots.	8 knots.
1000	310 lbs.	1250 lbs.	2800 lbs.	5000 lbs.
2000	540 "	2050 "	4800 "	8600 "
3000	675 "	2700 "	6050 "	10800 "
4000	830 "	3300 "	7500 "	13500 "
5000	960 "	3800 "	8600 "	15000 "
6000	1075 "	4250 "	9500 "	17000 "

Note that if the vessel towed is long and fine, the resistances will be less than those above, while if she is short and bluff, they will be greater.

It must be understood that the resistances of the above table suppose the vessels *to be actually moving with the speeds given.* When the tow is at rest, the problem of overcoming her inertia and getting her up to the uniform speed desired, is very different from that of towing her after she acquires this speed; and as something of a jerk is inevitable, it is essential to use a line considerably longer and stronger than would be necessary for steady towing.

The tauter the line can be made before the towing vessel starts her engines ahead, the better it will be. She will of course start as slowly as possible, and, having overcome the inertia of the tow, work up, a fraction of a turn at a time, to the speed required. In gathering way at the very beginning it is well to give a few turns ahead, then stop the engine, then give a few more turns and stop, and so on.

To the resistances of the above table must be added a large percentage for the dragging screws of a steamer. This may be as much as 75 per cent of the resistance of the hull alone. Moreover, the resistance increases very rapidly—and, what is of more importance, becomes very irregular—where we have to deal with even a very moderate sea, especially if the sea is ahead. The wind must also be taken into account, its effect varying with the cross-sectional area exposed by the tow.

As a rough rule we may say that the resistances given in the table should be multiplied by a factor of 3 or 4 for what may be called " average " conditions of wind and weather at sea, and that this factor should be increased to 5 or 6 where conditions are distinctly unfavorable.

Where a very large ship, like a battleship, is to be towed, it is safe to say that 8 knots is about the maximum speed which should be undertaken with any lines which are likely to be available. It will be seen from the table of resistances for smooth-water towing that the resistance added by an increase of a knot rises very rapidly as the speed increases.

This point becomes very marked as we go above 8 knots, and it seems probable that any promise of gain in time based upon a gain of one or two knots in speed of towing will be much more than off-set by the delays due to failure of the lines.

The remarks which have already been made as to the advantage of a very high factor of safety in the towing arrangements are of course emphasized in the case where the ship to be towed is a large and heavy one, and practical experience in long-distance towing cannot fail to demonstrate the wisdom of making this factor much larger than is likely to seem necessary in the beginning.

§ III. TAKING A DISABLED VESSEL IN TOW AT SEA.

In good weather, this manœuver presents no especial difficulty and calls for no extended discussion. The lines are run and secured as already described. The towing vessel starts ahead slowly on the course upon which the disabled vessel happens to be heading, using every precaution to prevent a jerk on the line, and waiting, before changing the course, until both ships have gathered way and are moving steadily with a good tension on the line.

In very bad weather, on the other hand, towing should not be attempted unless exceptional circumstances make it necessary; as the running of lines in a heavy sea is attended by considerable difficulty, especially if the vessel to be towed is unable to assist by placing herself in a favorable position. Moreover, in really heavy weather, it would be necessary to proceed so slowly that little or no time would be lost by waiting for the weather to moderate.

It will be considered in the discussion which follows, that the weather is rough enough to call for the use of all reasonable precautions, but not rough enough to make towing impracticable. It may be assumed that the disabled vessel will be lying with wind and sea a little abaft the beam;—this being the position which a steamer usually takes up when lying in a seaway with engines stopped. The other vessel places herself on a parallel heading, either to windward or to leeward. In considering which of these positions is to be preferred, we must remember that a considerable time will be required to run the lines; and that, during this time, both vessels will be drifting to leeward at a rate which may make their drift a very important factor in the problem of manœuvring. A vessel which is light will drift faster than one which is loaded, the drift of a vessel in ballast-trim amounting often to several knots an hour. If the lighter vessel is to leeward, she will drift away from the other, making it very difficult to run the lines. It may be said, therefore, that as a general rule, if there is any important difference in the rate of drift of the two vessels, the lighter one should be to windward when the work of running the lines is begun.

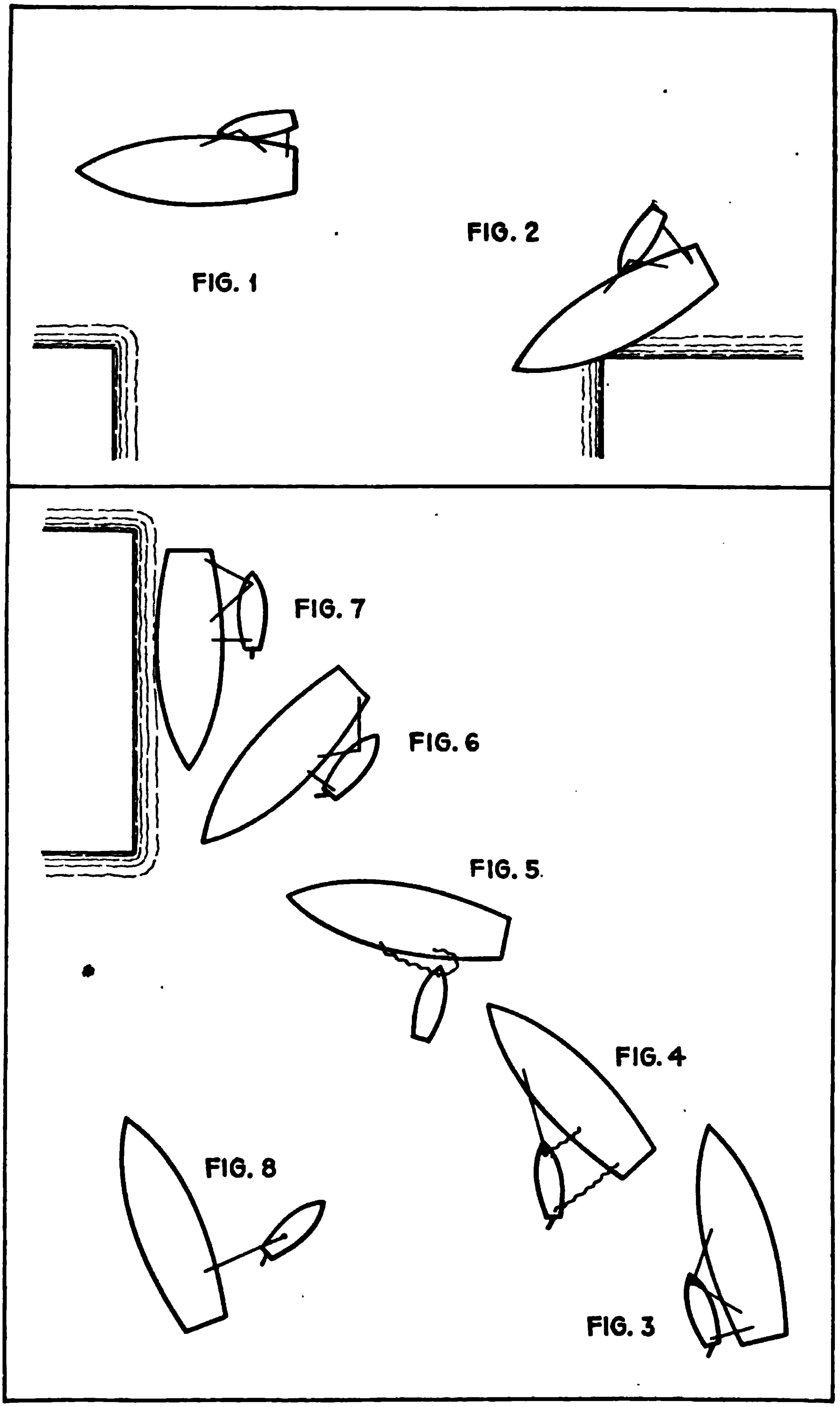
If there is any doubt as to which vessel is drifting the faster, this can be determined in a few moments by placing the one which is able to manœuver, in line with the other and on the same heading.

The towing vessel, then, places herself to windward if she is drifting faster than the other vessel, and to leeward if she is drifting more slowly, and on the same heading as the disabled vessel; taking care of course, not to run any risk of drifting into collision, and remembering, as the ships draw together, the caution already given not to get so close that the helm cannot be put over for hauling off without danger of throwing the stern into collision with the tow.

The vessel which is to leeward uses oil freely, creating a "slick" in which the boats can work.[1]

Some seamen recommend placing the towing vessel to windward and heading up to the sea or nearly so. But to hold her up in this position it would be necessary to keep the engines

[1] The oil from a vessel drifting in a seaway will not spread to leeward as fast as the vessel will drift. It is therefore impossible to make an oil-slick on the lee side, except, perhaps, very close aboard.



TOWING ALONGSIDE—TURNING A TOW.

turning, which would result in drawing away from the other vessel and add greatly to the difficulty of the situation.

Where the difference in the rate of drifting is considerable, the time available for running the lines after the work is once begun will be short at best and every precaution should be taken to prevent delay; a clear understanding being established between the ships and all preparations made, before the towing ship takes her position as above. In communicating between two ships, megaphones are of the greatest value. Under any except the most unfavorable conditions, they should make it possible to perfect a thorough understanding of what is to be done and how. They also to a great extent take the place of signals between the two ships after the towing begins, although a code should by all means be adopted and will be useful under many conditions. It is an excellent plan, when feasible, to send an officer on board the tow to remain there permanently; acquainting him first with the plan to be carried out and providing him with a list of whistle- and sight-signals for handling the lines and the ships. If no boats are to be used, a paper should be floated across to the tow, giving full instructions and a list of the signals. This may be sealed up in a bottle and attached to the rope or the float. Whistle signals are preferable to flags, because they can be used at night or in a fog.

The following is suggested:

Code of Sound Signals for Towing.

A short blast must not exceed 2 seconds in length.

A long blast must not be less than 6 seconds in length.

I am putting my rudder to right[1]	1 short blast.
I am putting my rudder to left[2]	2 short blasts.
Go ahead	2 long.
Stop	1 long, 2 short.
All fast	2 long, 1 short.
Haul away	2 short, 1 long.
Let go	2 long, 5 short.
Pay out more line	1 short, 2 long.
Avast hauling	3 short.
I am letting go (emergency)	5 short, 5 short, 5 short.

1. right rudder is port helm. 2. left rudder is starboard helm.

The first line to be run will be a light one, by means of which the heavier ones can be hauled across. A 3-inch manila is a convenient size to begin with. If new, so much the better, as it will float freely. If a boat is to be used it should be lowered with the crew and the greater part of the line in it, and gotten clear as quickly as possible, the line being paid out as the boat pulls away for the other ship.

If it is not thought best to use a boat, the line may be floated alongside the disabled ship without much difficulty. The best way to do this will depend upon circumstances, but a common way is to float a good length of the line by life-belts, casks, or any other convenient means, and to steam slowly around the disabled vessel, dragging this astern and causing it to foul her. If proposing to take up a position on her weather bow it is a good plan to steam along to leeward, fairly close aboard, cross the stern, and come around parallel to her heading. This will cause the line to foul her stern, which entails a little trouble in shifting it forward, but it leaves the towing ship in position without further manœuvring. Similarly, if proposing to take a position on the lee bow, pass along to windward, cross the stern and come around to leeward. The line should be picked up without difficulty.

Many vessels are provided with guns throwing a line-carrying projectile similar to that used in the Coast Guard Service (see Chapter XXIX and Plate 185). This is very useful and may save a great deal of trouble and delay.

An ordinary ship's rocket affords another and an excellent method of establishing communication. Such a rocket will carry a small fishing-line over 200 feet athwart the wind. If proposing to use this method, it will be better to go to windward and as close as is prudent. The fishing-line is faked down on deck, clear for running, with one end fast on board and the other bent to the rocket stick a few inches from the end. The rocket is given a good elevation (about 45°), and fired. If connection is successfully made, a somewhat heavier line is bent on and hauled across and so on until a sufficiently heavy one has been run to haul over the tow-line. If the wind is blowing across, it will carry the bight of the line and hence the tail of the rocket, to leeward, causing the rocket to work up to windward. Allowance must be made for this.

There may be special circumstances which will make it desirable for the disabled vessel to run the lines, but under ordinary circumstances it is more convenient for the towing vessel to run them. Having gotten the first light line across, by whatever method, the heavier lines are run and made fast to the bower-cable of the vessel to be towed. A good length of cable is paid out;—60 or 75 fathoms is none too much for heavy work;—and the line made secure on both ships as has been described in § I, chafing-gear being used liberally wherever it can be needed. In the meantime, full instructions about starting are given to the Chief Engineer, and when all is ready the engines are started ahead as slow as possible, and stopped the moment the line begins to tauten out; then a few more turns are made, and so on until the inertia of the tow is overcome and both ships are moving slowly with a steady tension on the line. The revolutions are then increased little by little and the course changed gradually, as may be necessary. When, finally, the tow is straightened out and moving steadily, the speed is worked up to that at which it is thought wise to continue.

In all changes of course, the tow puts her helm at first to the side opposite that of the leader, and so steers around into the leader's wake.

If the sea is such as makes it dangerous to tow to windward, it is worth while to consider whether a port cannot be made on a course which will present fewer difficulties, even if the distance is much greater.

After settling down to a steady rate of towing, the lines should be examined, springs hauled taut afresh, the strain divided as evenly as possible, chafing gear renewed wherever necessary, etc. Hands should be stationed night and day to watch the lines on both ships, with axes and unshackling tools ready for slipping hurriedly if necessary. It is well to have a light "messenger" line between the ships, for hauling messages across and for use in running a new line in case of necessity. This line should be left slack and should have ample length to allow for the fact that if the tow-line parts the leading ship will forge ahead considerably before she can be stopped. If such a line is not used, messages may be floated across by paying out and hauling in a light line like an old-fashioned log-line.

The towing vessel should use oil freely as in Plate **160.**

Standard Towing Equipment, United States Navy.

All capital ships of the United States Navy carry the Standard Towing Equipment shown in Plates **179** and **180.**

The approved method of taking a vessel in tow is as follows:

Directions for Towed Vessel. Unshackle both bower cables at the five-fathom shackle, each anchor having first been secured by two housing-stoppers on the five-fathom shot. Reeve the free ends of the bower cables out through the bow chocks, bring them in on the forecastle and shackle them together, forming a bridle, taking care to have all clear for veering the bridle outside when ready.

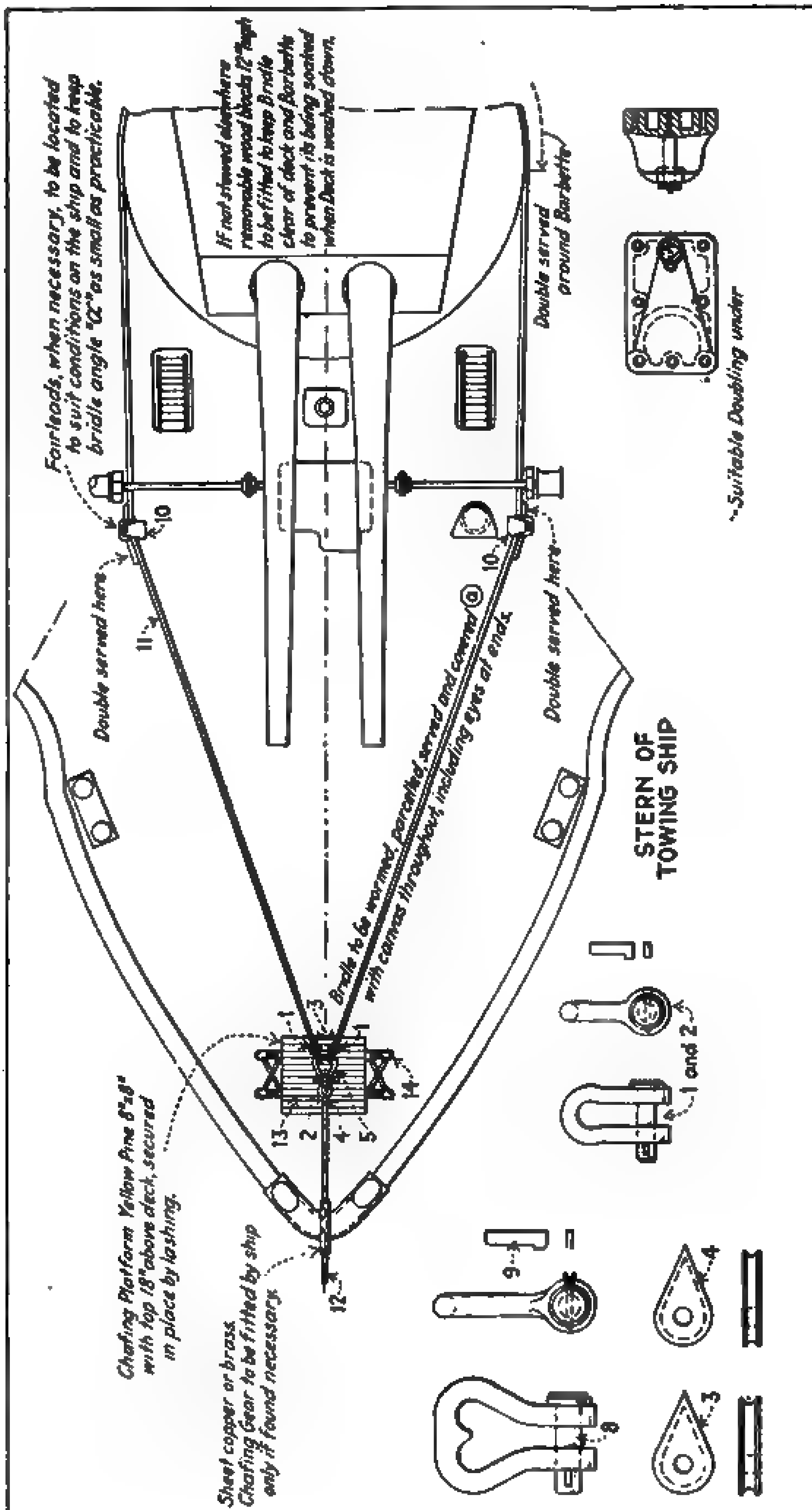
Shackle the end of the steel towing hawser to the bridle and flake the hawser on the forecastle, clear for running. Remember that the end which is shackled up to the bridle will go out last. Put check-stoppers of one-inch manila on the bights of the hawser to check it when it is payed out.

Bend a 3-inch manila line to a spar. Put the spar overboard and pay out the line. The spar will probably drift to windward; or, what amounts to the same thing, it will drift to leeward more slowly than the ship.

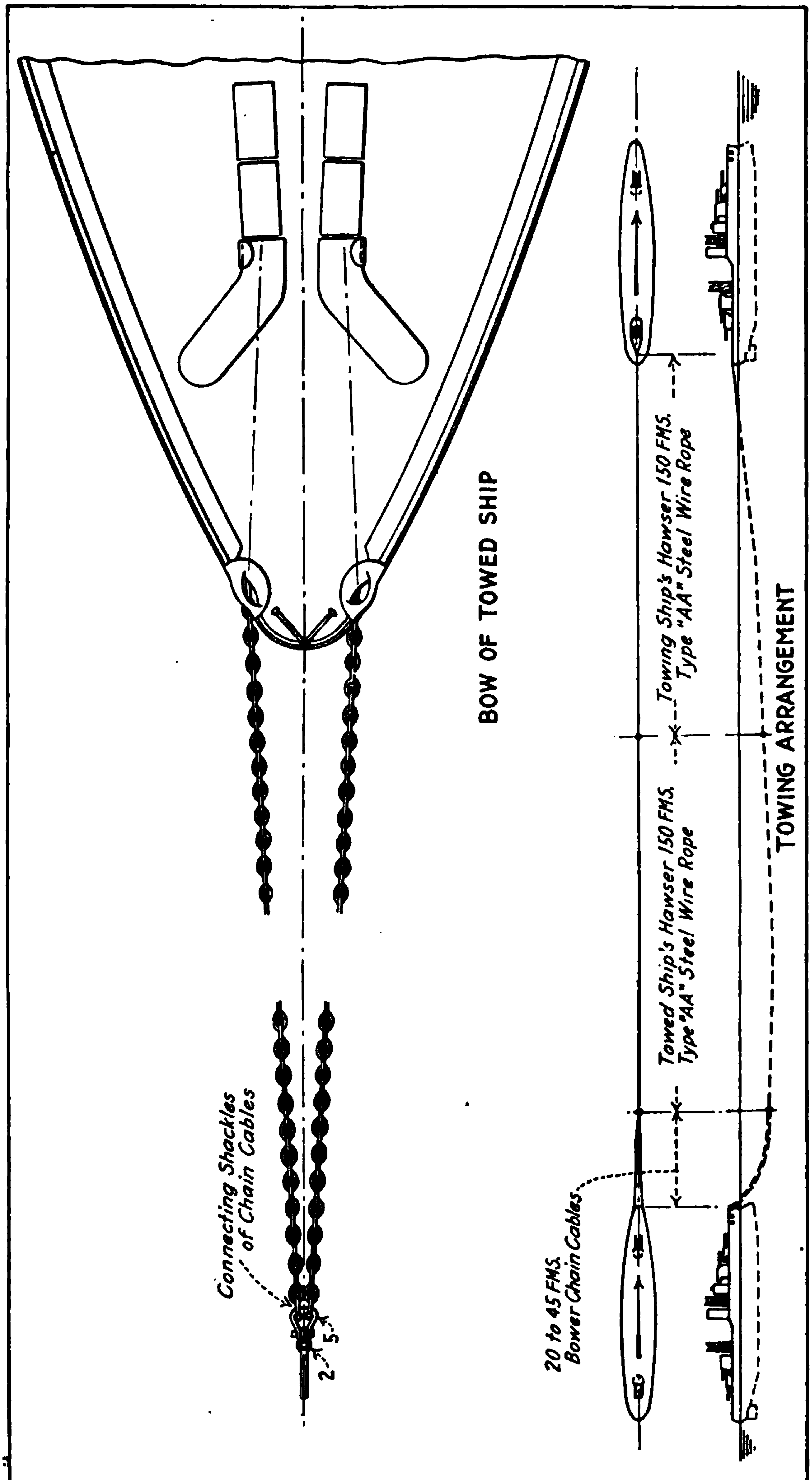
Directions for Towing Ship. Take position about one-half mile astern of the ship to be towed, and a little to windward. Secure the bridle around the turret. Flake down the towing hawser (2½-inch diameter wire), shackling one end to the bridle and the other to an 8-inch manila hawser, this hawser being also flaked down clear for running. To the free end of the 8-inch manila line bend one end of a 3-inch manila line which has been led aft from the forecastle, outside of all, and in through the stern towing chock.

All being ready on both ships, the towing ship steams slowly up to the spar,—the location of which is signalled by the towed ship—picks it up (on the forecastle) and bends the 3-inch manila line which the spar has floated across, to her own similar line leading from aft. The bight of the 3-inch lines is then thrown overboard, and the towed ship takes in the slack. When the line is clear of the screws of the towing ship she manœuvres to gain a favorable position, the 3-inch line being payed out as is found necessary by the towed ship. When a favorable position has been attained, the towed ship hauls in the 3-inch line, followed by the 8-inch, and finally by the end of the steel towing

Plate No. 179.



STANDARD TOWING GEAR, U. S. NAVY.



STANDARD TOWING GEAR, U. S. NAVY.

hawser. The two towing hawsers are shackled together, and payed out. When the chain bridle is reached (on the towed ship) it is payed out carefully and the two cables are veered away to whatever scope is considered advisable. Sixty fathoms is recommended.

The precautions to be observed in starting ahead and in increasing speed have been detailed in an earlier part of this Chapter.

§ IV. TOWING ENGINES. TOWING ALONGSIDE.

Towing Engines. (Plates 181 and 182.) In the United States, vessels designed especially for towing are in most cases fitted with towing-engines, which carry the line on a reel and pay out and haul in automatically as may be necessary to keep the tension constant; the resistance of the tow being borne entirely by the steam pressure in the cylinders. If the tension on the hawser rises momentarily above this steam pressure, the drum revolves and pays out line. This action opens the regulating valve and increases the steam pressure in the cylinders until this pressure balances the tension on the line. If, later, the tension decreases, the steam pressure will be in excess and the drum will revolve and reel in the line, but at the same time the regulating valve will close in part, and the pressure will fall until it meets and balances the tension. In this way, the line is paid out or reeled in only just enough to meet the condition of things prevailing at any given moment, and the average length of line remains practically constant.

There can be no question of the enormous advantage in towing resulting from the use of these engines. A point of great, though perhaps secondary, importance, is that if the towing vessel stops, or if for any other reason the tow ranges up and slacks the line, the engine takes in the slack at once and keeps it clear of the screw. If it is found desirable at any time to shorten in the line, reducing the distance between the vessels, it can be done without difficulty. This may be important in passing around bends in a channel, or for taking in the line preparatory to casting off.

It is not the least of the advantages of the towing engine that it makes the use of wire-rope perfectly safe in all weathers.

Towing Alongside. When towing in port or in confined waters, the tug should be made fast alongside if possible, as this gives

TOWING ENGINE (LIDGERWOOD).

TOWING ENGINE (LIDGERWOOD).

greater ease and certainty in handling. When used in this way, the tug is usually placed on the quarter, where its rudder acts with that of the tow, for steering. As the power is applied at a distance from the midship line, there is here a considerable turning moment, which will throw the ship's head to one side or the other, according as the tug goes ahead or backs; the effect being exactly as if the ship had twin screws and was using only one of them. In going straight ahead, the turning effect is neutralized by a small amount of helm.

The tug must be made fast with a line from aft for going ahead and one from forward for backing. Both of these lines are usually made fast at the bow of the tug, her stern being held from swinging out by a breast-fast leading to the tow (Plate 178).

If the tug has a right-handed screw, she will handle better if made fast on the port side; since, in backing, the tendency of her screw is to throw her stern out to port, while the tendency due to her position on the port side of the tow is to throw the stern of the tow the other way. Thus she will make a straighter sternboard than if made fast to the starboard side, where both these elements would tend to throw the stern off to port.

If, however, there is a sharp and difficult turn to be made, the tug should be on the inboard quarter; that is to say, on the side toward which the turn is to be made. Here she will be properly placed for *backing* to assist in the turn. So long as she is going ahead, she would be more favorably placed for turning, on the outboard side; but if her turning effect when so placed should prove insufficient for the turn she would be helpless. To back, under these circumstances, even for keeping clear of the beach, would only make matters worse. It is, therefore, the practice of tug masters to place themselves on that side of the tow toward which they wish to turn, *if the turn is one which involves some difficulty.*

It sometimes becomes necessary to turn the larger vessel on a pivot; that is to say, without going materially either ahead or astern. Suppose the tug is on the starboard quarter and wishes to slew the stern of the tow to port (Plate 178). She lets go her stern breast and goes ahead with left rudder,[2] holding on to the "go-ahead" line. This throws her stern out and she puts her bow (usually protected by a good fender) against the stern of the tow and pushes it around.

2. left rudder is starboard helm.

If it is desired to pull the stern to starboard, she lets go both lines from her bow, slacks the after-line, and swings off clear, going ahead as in Fig. 8. Observe that for this manœuver it is necessary that the line used for towing should lead from a point on the tug far enough forward of the rudder to let the tug's stern swing freely. She will then be able to head in any direction desired, even though there may be a current setting her down.

This is perfectly simple in the case of a tug whose towing bitts are placed well forward as is usual with tugs. In the case of a vessel not fitted in this way, the line may be taken through a side-chock fairly well forward, the vessel in this case being held up by the helm as in Fig. 1, Plate **183.**

It sometimes happens that a vessel towing another alongside wishes to "wind" the tow to put her alongside a dock, the side on which the towing vessel is secured being the side which must be put to the dock. This is a manœuver which may be seen almost any day in a harbor like New York, where a tug, towing a barge and having the barge, say, on her starboard side, wishes to land the barge alongside a dock which is on the port hand, and at the same time to get herself clear of her position between the barge and the dock. Plate **178** makes it clear how this manœuver is performed. (But see description in Chapter XVII.)

CHAPTER XXVI.

RESCUING THE CREW OF A WRECK.

The situation here is somewhat like that where one ship is to take another in tow, but with several important points of difference. No matter how bad the weather may be, the work of rescue, if it is to be attempted at all, must usually be undertaken at once; and in practically all cases, by means of a boat. On the other hand, the rescuing ship is much freer to manœuvre than when she is hampered by lines as in making preparations for towing.

The natural way of proceeding under ordinary circumstances is to go to windward of the wreck and lower a boat, then go to leeward and stand by to pick it up. If oil is used along the weather side of the wreck, the boat will have an oil-slick, in addition to the lee afforded by her own vessel; and if the rescuing vessel uses oil after getting into position to leeward, the slick may be continued so that the boat shall have the benefit of it as she returns, loaded, before the sea. If for any reason the wreck cannot use oil, the rescuing vessel can steam around her, running oil freely and so creating a slick into which the wreck will presently drift.

If the weather is very rough, extreme precautions will be called for in lowering the boat and getting her clear. The ship should be held up with the sea on the bow, giving a lee for the boat and reducing the rolling as much as possible. The crew is lowered in the boat, with life-belts on. A painter is used from well forward, brought in on the inboard bow of the boat and tended with a turn around a thwart, and the steering oar is shipped in its crutch, ready to assist in sheering off clear of the side as soon as the boat is in the water. Frapping lines may be used around the falls to steady the boat, and sails or mattresses hung over the side as fenders, to prevent the boat from being stove if she swings in heavily. Two or three extra life-belts should be taken along, with two heaving lines bent to each. These are

for hauling back and forth between the boat and the wreck. Oil-bags should be hung from the bows of the boat.

As the boat strikes the water, or just before it becomes water-borne (depending upon the type of detaching apparatus in use), the boat is detached and the painter passed quickly aft and hauled in, shooting the boat ahead and sheering her off at the same time. The vessel should be nearly dead in the water when the boat is lowered, but a little headway may be needed to keep her up to the sea.

Assuming that the boat gets off and makes the trip to the wreck in safety, the officer in charge must decide how he will establish communication and take off the passengers and crew. It is out of the question to go alongside to windward; and if he goes alongside to leeward, not only is there a risk of being stove by the wreckage which is likely to be found floating under the quarter, but there is the much more serious danger of being unable to get clear of the side again. As has been explained in the Chapter on Towing, a vessel lying in a seaway with engines stopped drifts to leeward at a rate which is always considerable and may amount to several knots an hour. A boat alongside such a ship, to leeward, is in exactly the same position as if she were alongside a dock against the face of which a strong current is setting. Every one knows how helpless a boat is under these conditions so far as getting clear is concerned. As a rule, then, the boat must never be brought actually alongside the wreck. She may either lie off to windward, keeping well clear and being held up head to sea by the oars, or to leeward, holding on with a line from her bow to the wreck, with a few oars at work backing, to keep her at a safe distance, and at right angles to the keel line of the wreck. If obliged to go alongside, the stem may be allowed to touch, all being ready to back off if the boat shows a disposition to get broadside-on. It may be well to let the men at the oars face forward to make sure of being able to keep off. The people on board the wreck put on the life-belts, jump overboard one at a time, and are hauled into the boat. In most cases the most favorable point for working will be under the lee quarter or the lee bow, depending upon the way the wreck is lying with reference to the sea. It is sometimes possible for people to lower themselves or be lowered to a boat from the head-booms or from an overhanging main-boom, when they could not be rescued in any other way.

So serious is the question of avoiding actual contact with the wreck, that many officers consider it best for the rescuing ship to go to windward and drop the boat down with a line, putting only two or three men in the boat. This is the plan recommended by Captains Todd and Whall in their Seamanship, and it is endorsed by a number of experienced officers who have favored the present author with their views; but a large majority of the officers who have written on this subject take the ground that a boat is always safer and more manageable with a full crew, and that to drop her down with a line from the ship simply hampers the manœuvring of both the ship and the boat without any sufficient compensating advantages. If proposing to drop the boat down with a line, it is important to make sure of having this of sufficient length. One end should be passed through the bow ring-bolt and hitched around a midship thwart. It is well to have fifteen or twenty fathoms of spare line in the boat for use when close to the wreck, as this gives the people in the boat control of the situation at the time when too much or too little may be of vital consequence. There should be certain men of the crew specially stationed to tend the line, signal the ship, throw the heaving line to the wreck, etc., for there will be no moment during the rescue when either the steering oar or the line should be left unattended. A life-belt or buoy should be taken, in this case as in the one previously described, with two lines for hauling it back and forth between the boat and the wreck.

Oil-bags are hung from the quarters of the boat and oil used by the wreck, as in all cases of this kind. If the wreck cannot assist in this way, the rescuing vessel should pass along to leeward (at a good distance) running oil freely. The wreck will soon drift into the slick thus created.

The boat is dropped down by paying out line on board, being kept head to sea by the steering oar assisted by the drag of the line over the bow. The line must be kept in hand on board the ship, to insure a prompt response to signals from the boat. The officer in charge of the work keep his glasses on the boat incessantly.

If the line is led through a midship chock on the ship and the ship allowed to fall off on a heading parallel with the wreck, she will drift with the latter, though perhaps not at an equal speed, and will change the distance very slowly if at all. She will, more-

over, be perfectly free to handle the engines slowly—going ahead or backing as may be necessary to keep in position for giving the boat a lee. If the attempt is made to hold her up to the sea, it will be necessary to keep turning the engine ahead, which will result in drawing away from the wreck. There will, moreover, be constant danger of fouling the screw with the line, and no lee will be created for the boat.

A simple code of signals must be adopted and fully understood, thus:

In the Boat.

Right arm extended,	Slack away on board,
Left arm extended,	Haul in on board,
Arm held up overhead,	Hold on.

The arm waved, in either of these positions, emphasizes the order. Thus, the right arm extended and waved up and down means "slack away roundly."

On Board Ship.

A long blast of the whistle,	"We are about to haul in."

When the boat is near the wreck, say within thirty or forty yards, signal is made to hold on to the line on board, and the men in the boat begin to pay out, dropping down as close as is thought perfectly safe, then floating the life-belt across. This is picked up by those on board and worked as has already been described. When the boat is loaded, the signal is given and it is hauled back to the ship. Here the greatest care must be exercised and the line hauled in very slowly, else the boat is certain to be swamped.

The method of dropping the boat down by a line from the rescuing ship has been described at some length because there are undoubtedly occasions on which it can be used with better prospects of success than other methods. In cases, however, where a boat can be used independently and untrammeled by a line from the ship,—as in the cases hereafter described,—it is believed that the freedom of action thus afforded the boat gives this method a very marked advantage.

If the weather is such that a boat cannot be lowered, the difficulties of effecting a rescue are greatly increased, but the situation is not necessarily hopeless. There are many ways of getting a line between the ships; as, for example, by a line-throwing gun, a rocket, or a float. If a balsa is available, the following method might give some hope: The rescuing vessel steams slowly across the stern of the wreck, towing the balsa by a very long line, and manœuvers in such a way as to cause the line (not the balsa) to foul the wreck. If the people on board can haul the balsa up to leeward and get on it there should be no great difficulty about saving them.

Another method which suggests itself is the following: Suppose it is apparent that the wreck is drifting faster than the rescuing vessel will drift if she stops her engines. The rescuing vessel goes to leeward and places herself, with engines stopped, in such a position that her bow is just clear of the line of drift of the stern of the wreck. If any miscalculation is made, a few turns of the screw astern will carry her clear. As the wreck drifts down, a line is gotten across by any means that is convenient and the people are hauled across. If the rescuing vessel drifts the faster she will of course go to windward instead of to leeward, and wait to drift into position herself. In this way it should be possible without imprudence to let the vessels come much closer than would be safe in any other manœuver that could be attempted.

The following extract from a letter received by the author gives a detailed description of several rescues by the writer of the letter, who is one of the most experienced officers of the International Navigation Company.[1] It will be noted that he believes in holding his ship as close as possible on the weather quarter of the wreck instead of going to leeward to pick up the boat; believing that more is gained by the lee afforded in this way than would be gained by the other plan.

In December, 1899, I was in charge of the boat from the S. S. *Pennland* that rescued the crew of the British Brigantine *Don Juan,* of Salcombe, England, in the North Atlantic. In the morning we discovered a vessel dismasted and rolling in the trough of the sea, the wind N.W., force about 7, and a very high sea. Getting closer to her, we saw that there were people on board of her. I got a volunteer crew and made the boat ready for lowering, taking in a couple of heaving lines, two buckets,

[1] Captain H. Doxrud, Steamship *Noordland.*

and a large can of oil. The *Pennland* was brought to windward of the wreck close to and with the wind and sea about 4 points on the starboard bow, heading about west. The boat was lowered with the full crew, 8 men, in it and a bridle around the falls from the main deck to prevent the boat from swinging too much when lowered; a line from the fore part of the ship in the boat. The boat was lowered very quickly, and on touching the water the patent hooks disengaged themselves, the bow-line was passed aft and a strong pull on it brought the boat's bow around and sheered it clear of the ship's side. We got the oars out immediately and pulled before the wind and sea toward the wreck, having good shelter of our own vessel. When we got close to the wreck we found it impossible to get alongside, as she was rolling heavily, the sea washing over her, and part of her rigging floating alongside. We got close under her stern with the boat and had a line thrown us from the wreck; to this we bent on our heaving line and a life-belt, which was hauled to the wreck, one end being in the boat. The life-belt was put on the first man to go and the bight of the line secured around him under his arms; he jumped overboard and was pulled in the boat. The life-belt was hauled back to the wreck, and by this means all the crew, 9 in number, were rescued. Our vessel was drifting in the trough of the sea with the wreck, close to; so a short pull brought us safely alongside.

During the rescue the boat's crew was placed as follows: two men in the bow to work the line, four men at the oars to keep the boat in position, one man bailing and myself steering (using a long oar instead of a rudder) and directing the work.

My second experience was in October, 1892, off the Flemish Cap—when Chief Officer of the S. S. *Noordland,* when I was in charge of the boat's crew that rescued the crew of the Norwegian Barque *Kong Oscar the 2nd.* The wind was N. W., force about 6, with heavy hail squalls. This rescue was very difficult and dangerous, as it was done during a very dark night, and took from 9 in the evening until 1 in the morning. The *Noordland* was brought to, to windward of the wreck, heading about west, when the boat was lowered in the same manner as on the former occasion, with 8 men in it. We got safely away from the ship's side. Coming up to the wreck, we found her waterlogged, the sea making a clean sweep over her, making it impossible to get alongside. The crew, numbering 16, was taken off by means of a life-belt and line, as on the former occasion.

The *Noordland* was drifting in the trough of the sea to windward, and we pulled up to her under her lee and got safely alongside and on board with our boat load of men. The boat's crew during the rescue was placed as on the former occasion.

My third experience was in October, 1899, when in command of S. S. *Rhynland.* When off George's Bank we fell in with the disabled and waterlogged British Brigantine *Ida Maud.* The night previous it had been blowing a gale from the S.E.; and at the time (about 3 P.M.), it was blowing from the N.W., force about 6, making a very nasty cross sea.

I brought the *Rhynland* to windward of the wreck, close to, heading about W.S.W., and lowered one of the port life-boats with a volunteer crew of 8 men, Chief Officer Daddow in charge. The boat got away from the ship all right and proceeded toward the wreck.

As on the former occasions, it was not possible to get alongside the wreck, the sea washing over her, and a lot of loose lumber floating about. A rope was thrown over the end of the main boom that extended several feet abaft the stern of the brigantine, the shipwrecked crew climbed out one by one to the end of the boom and dropped into the boat. In the meantime I had brought the "Rhynland" close to the wreck, her bow nearly in line with the stern of the wreck, thereby giving the boat shelter, and a short pull brought them alongside.

In these instances oil has been frequently used both from the rescuing vessel, the boats, and in the first instance from the wreck also, and I cannot recommend its use too strongly for work like this. Its effect is simply wonderful, and I attribute my success in the above cases without mishap greatly to a liberal and judicious use of oil.

An unusual case of the rescue of the entire crew of a foundering vessel in heavy weather without the lowering of a boat is that of the saving of the crew of the U. S. S. *James*, a mine sweeper, by the gunboat U. S. S. *Marietta*, Commander H. G. Hamlet, USCG, commanding, in the Bay of Biscay on April 28, 1919. In a gale of wind, with very heavy sea, the *James*, with fires out and water logged, was sinking. Weather and sea conditions made it impossible to attempt a rescue by boat; action of some sort was imperative if the imperiled lives were to be saved. The *James* was lying with wind and sea on her port quarter. The *Marietta* was placed for a while in the *James*' wake, and heading with her, in order to determine the comparative drift. As was to be expected, it was found that the *Marietta* drifted the faster. The *Marietta* was then placed with her bow lapping the lee quarter of the *James*, heading with her, and only a few feet distant, and a heaving line was passed on board. The *Marietta* was held in position, with the helm and engines, at a distance that at no time during the operation of rescue exceeded fifty yards. A 4-inch line was hauled on board the *James* and the bight was secured to a Carley life raft in such fashion that the raft could be hauled back and forth from one ship to the other. In this manner the entire crew of the *James*, 47 in all, were transferred to the *Marietta*, nine trips being made. The crew of the *Marietta* were stationed along the rail on the forecastle head with bowlines, and, as the raft came near the *Marietta's*

bow, a bowline was passed to each man on the raft and he was hauled on board. During the operation oil was used freely by throwing it overboard from the port side of the *Marietta;* on the *James* the heads of oil barrels on the after deck were broken in. Shortly after the *Marietta* had rescued the crew and backed clear the *James* sank.

A life raft, with sunken deck, is much better adapted to an operation of the sort described than is a decked life raft. Had a decked raft been used in this case the men would have been in danger of being swept off by the seas.

Another rescue of exceptional interest is that of the crew of the *Otranto* by the *Mounsey,* described on page 619.

CHAPTER XXVII.

MAN OVERBOARD.

The most immediate danger to a man falling overboard from a steamer is that of being struck by the propeller. This danger is especially great in the case of a vessel with twin-screws, and is of course increased in any case by throwing the stern to the side on which the man has gone over.

If the experiment is tried of throwing over from the bow a light buoyant object, it will be found that by the time this reaches the stern it will be clear of the side by a considerable distance, being thrown off by the surface wash from the side. A *man* falling overboard may feel this wash to a certain extent, but he sinks in the beginning far below its influence and into the suction of the screw. Moreover, his first instinct is to swim back toward the ship.

The first thought of a man falling overboard should be to swim outward from the ship, and the first thought of the officer on the bridge should be to stop, *not back*, the engines. If it is known from which side the man has fallen, the helm may be put hard over to the opposite side, throwing the stern away from him. This calls for quick thinking and prompt action; but the time available is by no means as short as might be supposed. A steamer 400 feet long, making 12 knots, passes over her own length in twenty seconds. Thus, if a man falls overboard amidships, he will be ten seconds in reaching the screw.

One or more life-buoys should be thrown over at once. If a little presence of mind is exercised here, it is often possible to throw one of these very close to the man.

At the first alarm, a number of men (previously instructed), jump aloft to try to keep the man in sight; and as quickly as possible a quartermaster follows them with a good pair of binoculars.

The ordinary life-buoy is so small that often the man in the water cannot see it, and it is of little or no assistance to the

look-outs who are trying to keep him in sight. This is a serious and often a fatal defect. It is well to keep a number of these small light buoys about the decks, to be thrown overboard on the instant by any one who may be near them; but in addition to these, there should be provided a more elaborate buoy or float fitted with a mast and a light, to be let go promptly and to serve not only as a buoy, but as a *marker*.

If to this is added a can stuffed with oakum soaked in oil, a *slick* will be created around the buoy which will not only be of great help to the man but may assist greatly in keeping the spot in sight.

The light should be of a nature to ignite upon contact with the water. What is known as the "Holmes Light" is of this nature and is much used in the English merchant service. In the absence of a buoy fitted as above described (or in addition thereto), lights of this kind should be carried on the bridge (or forecastle), to be thrown over by the lookout, without an order, at the alarm of "Man overboard!"

This use of a marker, as distinct from the idea of a buoy (though preferably connected with the buoy) is of great importance.

Objection is sometimes made to the use of lights like the "Holmes" on the ground that the fumes given off by them are always offensive and in some cases unbearably suffocating. This is a reason for not connecting them rigidly with the buoy. They may, however, be attached to it by a short line which would let them float at some distance from it. Of course a light which ignites by contact with water must be sealed until it is wanted, when it may be punched or torn open either by a simple tool attached to it, as in the case of the "Holmes," or by some automatic arrangement connected with its release, as in the case of the U. S. Navy life-buoy.

Men-of-war usually carry life-buoys of special types, fulfilling more or less satisfactorily the above requirements. One of these is usually suspended on each quarter.

There seems no reason why a steamer should not carry at the end of the bridge (or on an outrigger if the bridge does not overhang the water), a small life raft (Plate 67), of a size sufficient to carry a man comfortably, fitted with a mast and a light and with two or three water-tight pockets containing a small supply of provisions and water, and, perhaps, a few lights of the Holmes or some similar type which could be used to attract the attention of passing vessels, in the event of being left adrift.

Under ordinary circumstances the engines are thrown to full speed astern as soon as the man is clear of the screw, and a boat is lowered as soon as the speed has been reduced sufficiently. The boat pulls back in search of the man, guided by signals from the lookouts aloft, provided they have succeeded in keeping the man or the buoy in sight. Failing this, the boat cannot go far wrong if it pulls back on a course *opposite the original heading* of the ship; for although the steamer in backing will probably throw her head to one side, she will not usually gain a great amount of ground in that direction before coming to rest.

In most conditions of the sea, a boat may be lowered with reasonable safety at a speed of five knots; and we may assume that the distance required to reduce the speed to this will be from two to four ship's lengths, and the time, from two to four minutes.

If the weather is smooth or the sea from such a direction that there is no occasion for manœuvring to lower the boat, all this is simple enough; but if conditions are such as to call for *turning* wholly or partially before lowering, it is thought by many officers a good plan to put the rudder hard over, keeping the engines turning a h e a d, and to describe a circle, thus coming back, w i t h t h e s h i p, to a point near that at which the man went over.

Observations upon the turning circles of a large number of steamers show that a steamer turning with hard-over rudder will pass within a short distance—rarely so much as a ship's length—from the point where the helm was put down. No doubt the symmetry of the curve may be considerably modified by wind and sea, but not sufficiently to prevent a return to the neighborhood of the starting point. The time required for the full turn will vary with the length, the speed, the weather and the manœuvring powers of the vessel. Every officer should know the manœuvring powers of his own vessel, especially the size of the turning circle, the time required to describe it, and how close the ship will come to a marker thrown over just before putting over the rudder. (See Plate 115.)

Without attempting to lay down rules for the endless variety of situations which may arise in a matter of this kind, it will perhaps not be going too far to say that, generally speaking, the ship should be stopped and backed if she has the wind and sea ahead, or abeam, and that she would probably do well to turn, if they are much abaft the beam; since in the last case a boat pulling back would be working against wind and sea.

It will of course be understood that in turning, speed must be regulated according to the conditions of the weather. It would not do, for example, to come up into a heavy sea at full speed. (See Chapter "Handling a Steamer in Heavy Weather.")

If the conditions are such—due to the lack of a proper marker, or to fog, or to any other cause—that difficulty is to be anticipated in finding the man, it is probably better to stop and send the boat back along the course opposite the original heading. This emphasizes the importance of having a compass in the boat.

In case of fog, the vessel should avoid changing her position while the boat is away. The compass is thus a guide for finding the way back—assisted, of course, by sounding the whistle, firing guns, etc.

There can be no question that in weather too heavy to admit of lowering a boat, the one method that can give a hope of saving the man is to turn and attempt to pick him up with the ship.

In squadron. Special rules are laid down for cases of man overboard in squadron. It may be assumed that all officers concerned are familiar with these. Generally speaking, they provide for the necessary manœuvers to keep clear of other ships while picking up the man and for the signals notifying other ships of the situation.

They also direct what steps shall be taken by neighboring ships to assist in the rescue. Except when the ships are in column, the actual manœuvers on the part of the vessel losing the man are not greatly different from what they would be if she were acting singly, although in certain formations there might be difficulties connected with turning.

See "Man Overboard" in Chapter XXIV.

CHAPTER XXVIII.

STRANDING.

§ I.

The first impulse of an officer upon finding his vessel stranded is usually to throw the engines to full speed astern. This may be the right thing to do, but it is not always so. If the ship has struck a rock, the chances are that she will have a hole in her bottom, and to back off may result in sinking her without leaving time even for saving life. If aground on a soft bottom, to work the engines either way may result in disabling them by filling the condensers with sand or mud. Again, where a single-screw steamer is aground forward, backing the screw may slew her stern around and put her on the beach throughout her full length. These are points which should be taken into consideration in deciding whether or not to back the engines immediately.

Assuming that, for whatever reason, it proves that the vessel cannot be backed off at once, the most urgent step to be taken is to lay out an anchor and get a good strain on a line from this, for holding the ship from being set farther up on the beach. Such a line, kept well taut, will sometimes start a ship off quite unexpectedly by the steady pull which it exerts;—a slight rise of the tide or a little working of the ship by the wind or sea, contributing toward the same end. As the laying out of a large anchor involves delay when every moment may be precious, it is well to send out a kedge at once, following this as soon as possible with a stream or a bower. If there is a current setting along the coast, as frequently happens, the anchor should be laid out a little off the quarter, to keep the stern from being swept around. A buoy with a good buoy-rope should be used on the anchor. (See Chapter XII, *Carrying Out Anchors.*) While this work is in progress, careful soundings should be made around the ship on all sides, and a good leadsman stationed to note the rise or fall of the tide. The Tide-Tables, Sailing Directions, and Charts will of course be examined, the time of high water

determined, and the direction of tidal currents noted. If there is a chance that help will be needed, no time should be lost in communicating with shore and making such arrangements as the situation calls for. The immediate assistance of a vessel large enough to carry out a heavy anchor may be of the greatest value. It may be possible to secure a fishing vessel for this. If a tug can be secured, this may be the best use that can be made of her in the beginning.

An examination of the ship should be made as soon as possible after she strikes, and all compartments sounded. As already noted, this is particularly important on a rocky coast. If a compartment is found to be holed, the water-tight doors leading to it should be closed, the bulkheads braced, and the pumps put on, to keep the water down. If the hole is a large one, there will probably be danger in hauling off before stopping it at least in part. Repairs of this nature (before hauling off) can only be made from the inside.

When measures have been taken to prevent the ship from being set farther up the beach, *and not until then,* the work of lightening her may be begun;—ballast tanks pumped out, cargo shifted, lightered, or thrown overboard. If the ship is aground forward, something may often be gained by filling the after ballast tank or otherwise adding weight aft; as, for example, by shifting coal from an extreme forward to an extreme after bunker.

Getting out the boats is a quick and simple way of lightening the ship. They may be filled at once with provisions and other stores of such a nature as to be handled quickly, these being taken first of all from the forward holds—assuming the ship to be aground forward. If the beach is near, this freight may be landed and the boats brought alongside to be loaded again.

A man-of-war, with a large crew and plenty of boats, should be able under these circumstances to get rid of several hundred tons of easily handled stores within an hour or two. At the same time, the work of shifting weights from forward to aft can be going on, those articles being chosen first which lend themselves to "man-handling," such as boxes of provisions, bales of clothing, ammunition (except very heavy projectiles), cordage, etc. Much is gained if the conditions admit of letting go the anchors immediately and paying out the cables. This alone, if quickly done, might suffice to float a ship which was only lightly aground

well forward. But this will be dangerous if there is any chance of the ship being driven farther up so that she may strike on the anchors. It is a good rule in any case of letting go an old-fashioned anchor when aground, to unstock it and foul the flukes with several turns of cable.

All water in tanks forward should be pumped overboard. Nor should it be forgotten that one thousand men assembled aft gives a weight of approximately one hundred and fifty thousand pounds to help lift the bow.

When conditions become favorable for backing and hauling off—which will of course be at high water—the chances of success will be greatly increased if the ship can be moved in her bed, either by rocking her from side to side or by slewing her stern a little. This may perhaps be done by means of a line to an anchor laid out on the beam or quarter.

Vessels have been worked loose from a sandy bottom by *going ahead* with their engines; the suction current drawing aft along the bilge acting apparently to scour out the sand.

If another vessel comes to your assistance, she should, as a rule, anchor to seaward of you, with a good scope of chain, get good lines from your stern, and heave these taut until she tails in toward you or as nearly so as the wind and tide permit. If she then starts her anchor windlass ahead and keeps full steam pressure on it, she will not only keep the lines taut, but will take in and hold every inch that is gained on the line between the ships. When the time comes for a combined effort to haul off, she starts her engines ahead, still keeping the anchor windlass in action.

It is a good plan for the assisting vessel to lay out her own spare anchors well off shore with good lines bent to them, and to send the ends of these lines on board the stranded vessel. These will be heavier than the anchors that the stranded vessel could conveniently lay out for herself, and can be placed to far better advantage. This does not interfere with any of the other methods of assisting that have been described.

In cases where a strong current runs along the beach at certain stages of the tide, if the lines are hove taut at slack water, the current when it makes will be on the beam of the anchored vessel and will exert a tremendous force, with all the advantage due to the span formed by the anchor-cable and the tow-line. It would

be well here for the assisting vessel to have two anchors down. *And it is imperative that she should be prepared to cast off or cut the line between the ships without an instant's delay, in case she finds that her anchors are dragging and that she is being set down toward the beach.* Here, as in the case described below where the assisting vessel cannot anchor, it is desirable to lead the hauling line from a chock far enough forward of the stern to admit of using the rudder for holding the head up more or less toward the tide. She will thus be pointed toward safety if she begins to drag, and by starting the engines ahead with hard over rudder, the situation is changed into one resembling that of Fig. 1, Plate **183.**

In all cases like the above, of attempts to pull a stranded vessel off, there is danger that if she comes off suddenly she will collide with the vessel that is assisting her. The latter should therefore be ready to slip everything and get out of the way.

There is one possible advantage which results from having the towing ship under way. This is that if she does not start the other vessel by pulling directly astern, she can place herself on the quarter and may thus be enabled to slew the stern of the stranded vessel and so loosen her up in her bed.

Generally speaking, however, the difficulties are increased if the assisting vessel cannot anchor. It is almost impossible for her to keep a steady tension on the line, under the most favorable circumstances; and if the wind or the current is across, there is great danger that she will swing around on the tow-line and end by going ashore herself.

See Chapter on Piloting, where it is explained that in many places the full strength of tidal current corresponds with high and low water.

The only thing to be done where the assisting vessel cannot anchor is for her to lie off, head to the current, untill all is ready; then to run the line, *taking it from one of her own chocks fairly well forward*—not under any circumstances from the stern. She then heads more or less across the current and goes ahead, putting the strain on the line gradually and holding herself up against the tide by the helm, which will have good turning power because of the way the ship can pivot on the line (Plate **183,** Fig. 1). With the line led through a stern chock, the rudder would have no power, and the ship would be swept down helplessly

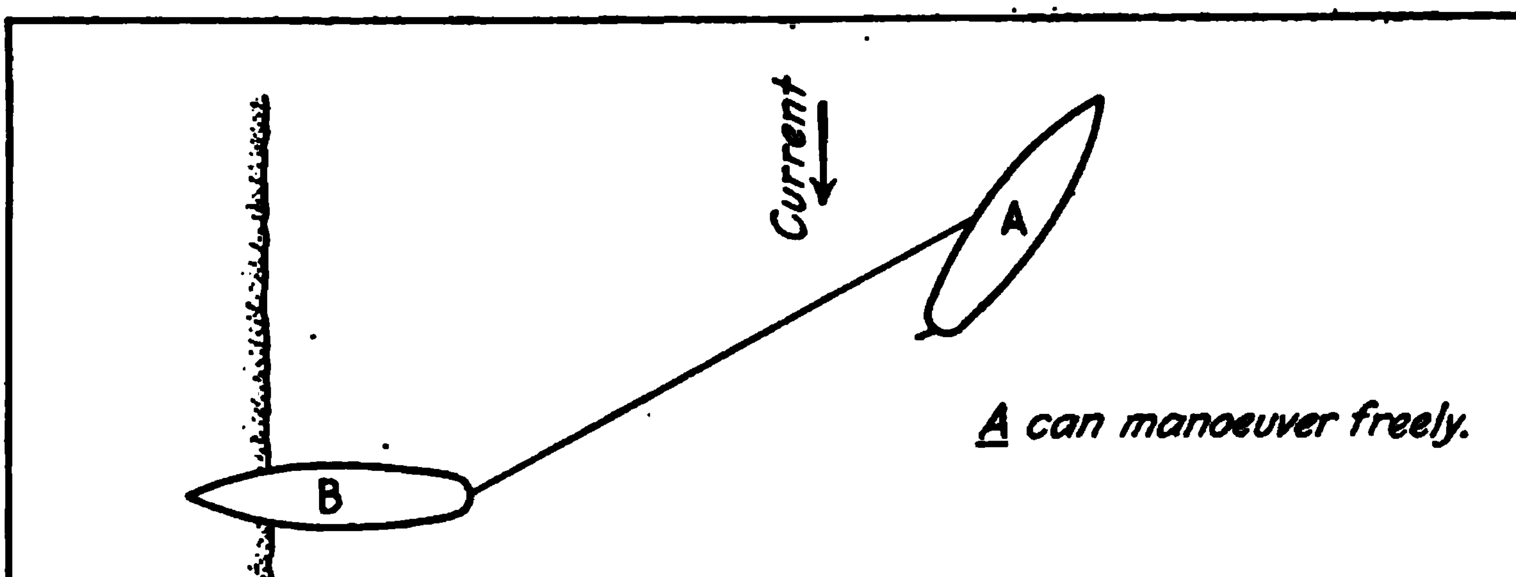


FIG. 1

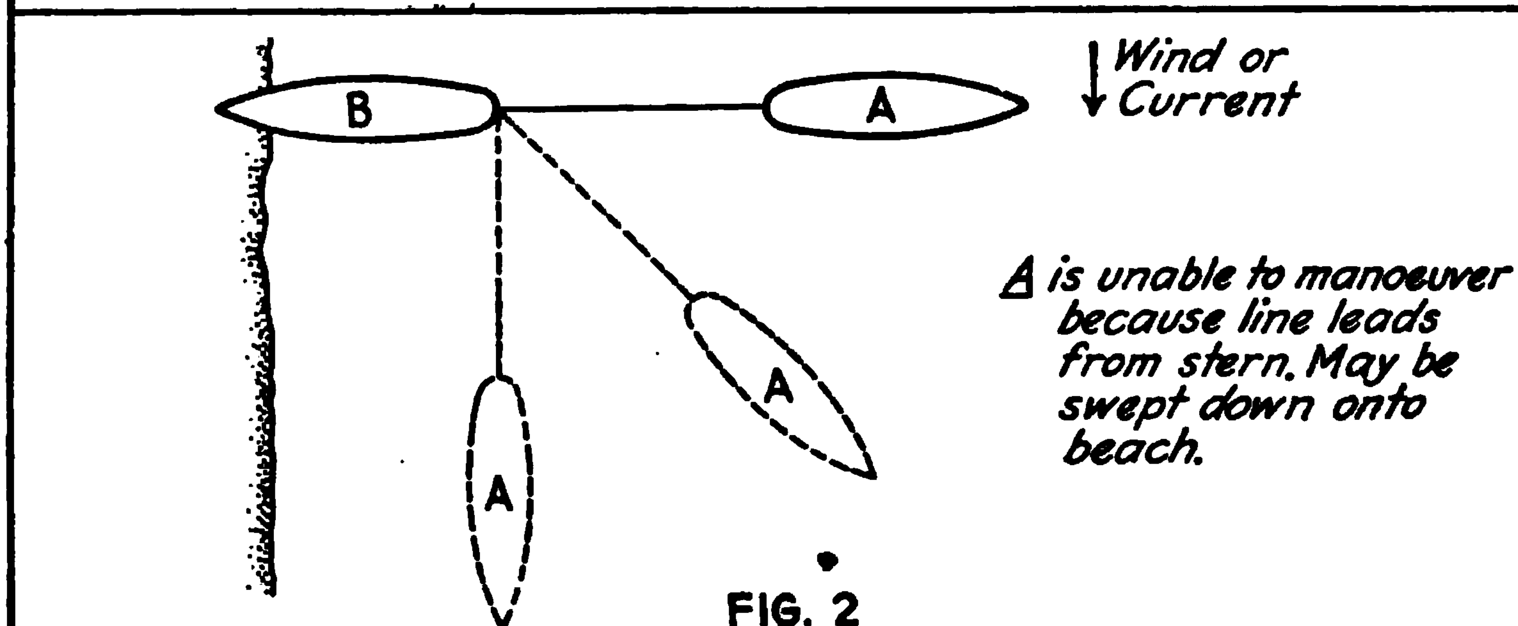


FIG. 2

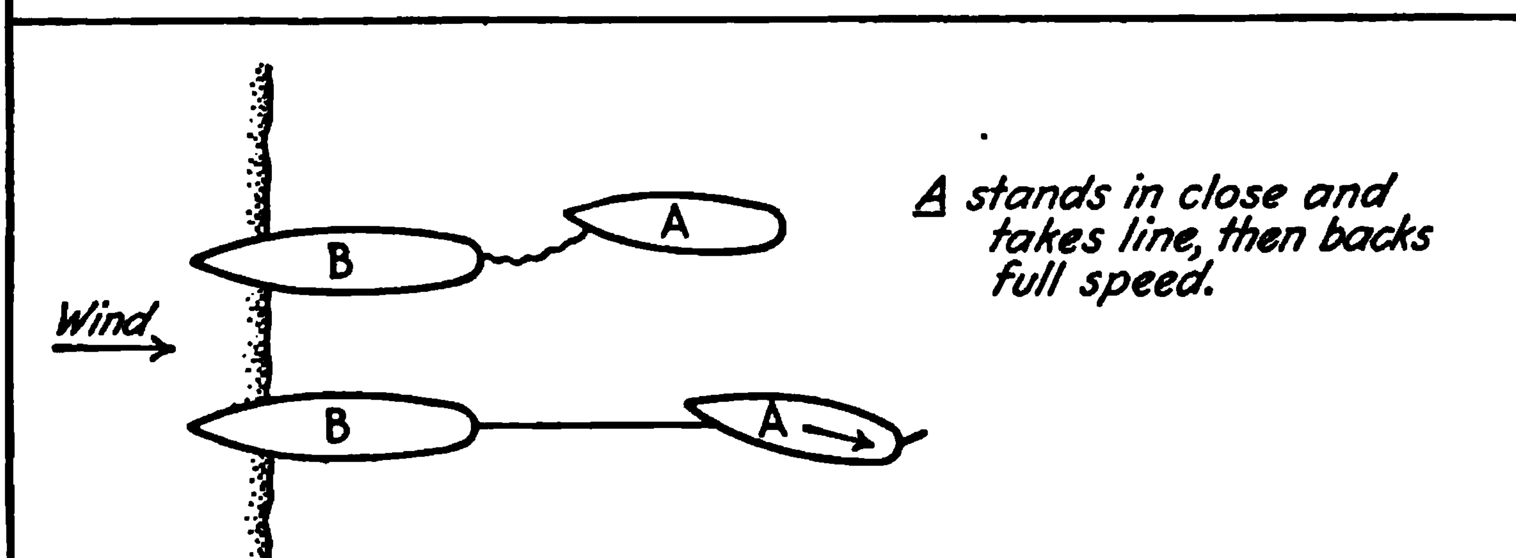


FIG. 3

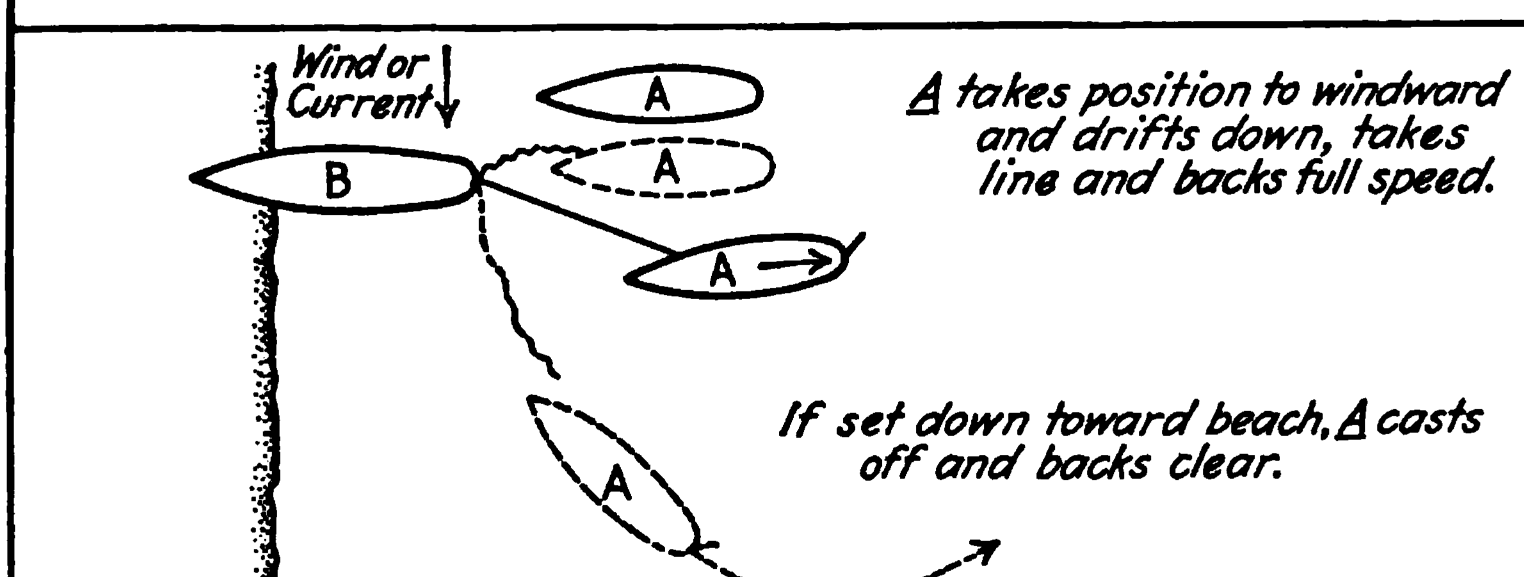


FIG. 4

ASSISTING A STRANDED VESSEL.

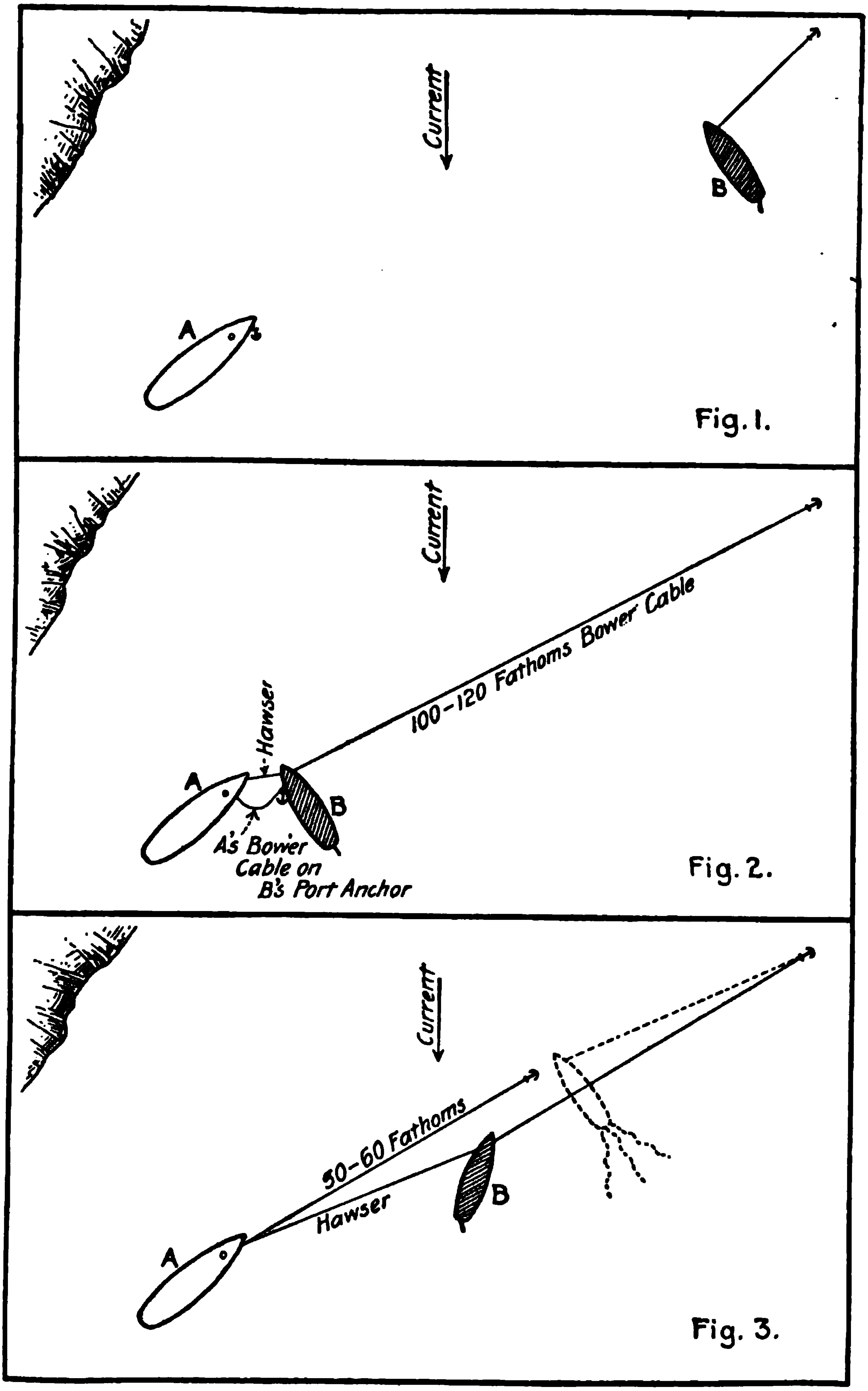
toward the beach unless she cut the line. (Plate **183**, Fig. 2.) Even when manœuvring as above described, an axe should be at hand to cut if necessary.

It may happen that the assisting vessel can approach *bows-on* to the stranded vessel and receive a line forward, taking it in through her own bow chock, and backing her engines to pull off. This may save much time which would be lost in manœuvring for position to take the line in aft and may make all the difference between being "just in time" and "just too late." Here again the importance must be emphasized of retaining the power to pivot on the line, by bringing it in through a chock some distance abaft the stem. (Plate **183**, Fig. 3.) This method is especially applicable if the wind is off shore. If the wind or current is setting down along the beach, the line must, in this case, as in that of figure 1, be run from the windward (or tideward) side.

In Fig. 4, Plate **183**, the assisting vessel stands in as close as is considered prudent, and a little to windward, and drifts down past the stern of the stranded vessel, to receive the line. If she is obliged to cut and get clear to save herself, she is helped by the tendency to throw her stern up into the wind which is a characteristic of all backing vessels.

If the draft of the assisting vessel permits her to go alongside she should be placed with her stern to the beach. If her bower anchors are laid out and her anchor engine kept running, this may be a powerful help. It may happen, too, that the current from her screw, going ahead with full power, will scour out the bottom under the stranded vessel.

There are, of course, many cases in which the effort to back off should be made immediately; as, for example, when it is known that the beach on which the ship has struck is hard and steep and not rocky. Here she will certainly be aground forward only, but there is great danger that she will swing around and ground throughout her whole length. And if this does not happen, the chances are that if there is any sea on she will be dangerously strained and perhaps broken in two. So here the one chance may be to back at full speed immediately;—not, however, neglecting other measures which do not interfere with it. If it is found that the backing is slewing her around broadside-on, the engines must be stopped. This is very likely to happen with a single screw. On a beach of this kind, it is particu-



HAULING OFF A STRANDED VESSEL.

larly important to get an anchor laid out immediately. A light kedge carried out at once on the quarter opposite that toward which she is inclined to swing around, may be of vital importance.

If all other methods fail, resort must be had to regular salvage operations, the description of which is beyond the scope of this book.

The following plan is recommended by an officer of long experience, as especially valuable in cases where a vessel is stranded on a muddy or sandy bottom (not rocky) and where another vessel goes to her assistance:

Referring to Plate **184.** *A* is aground, and *B* goes to her assistance. *A* being on the left side, facing the current, *B* drops her starboard bower anchor at a distance from *A* not ecxeeding her available scope of cable, and goes ahead with left rudder,[1] keeping the current on the starboard bow and allowing herself to be set over toward *A* until she is as close as is practicable, which will of course depend primarily upon her draft. *A*'s starboard bower anchor is now transferred to *B*'s port bow, if this can conveniently be done, by boats or otherwise; or, more simply, *A*'s starboard bower cable is unbent and the end is hauled across and shackled up to *B*'s port bower chain, disconnected at a convenient shackle.

At the same time a good hawser is run between the ships. If this hawser is run immediately, it will help to hold *B* in position while getting the chain across and may save some troublesome manœuvering in quarters perhaps uncomfortably close. Fig. 2.

Everything being ready, *B* starts her steam-windlass and heaves in her starboard cable, using her screw as before, but this time with the current on the port bow and more nearly ahead than before.

A, in the meantime, veers away her starboard cable, which is thus laid out by *B*. Fig. 3.

When *A's* cable is all out, or when no more of it can be laid out, *B* lets go the anchor and *A* heaves in on her cable, and makes fast the hawser connecting with *B*. At the same time, *B* heaves in on her steam windlass, and goes ahead with her screw. Thus we have the windlasses of both ships pulling on *A*, with the power of *B*'s screw added, and, still further, the "sucking" effect of the current acting on *B*'s port bow, and, provided *A*'s bow yields enough to cant her, acting on *A* as well.

1. Helm a-starboard.

CHAPTER XXIX.

ASSISTANCE BY PUBLIC VESSELS TO VESSELS IN DISTRESS.

The following chapter has been kindly prepared by two officers of the U. S. Coast Guard[1] and gives the "Doctrine" of that Service as developed through many years of practical experience with the problems involved in rendering assistance to vessels in distress.

One of the chief duties of the United States Coast Guard, in time of peace, is to render assistance to vessels in distress. The United States is the only nation that maintains a fleet of vessels whose primary function, during peace, is to afford aid to distressed vessels. A number of other nations maintain, or aid in the maintenance of, life-saving or lifeboat stations on shore to rescue the crews of stranded ships, but in none of these is the number of such stations so large as in the United States, nor are the stations part of a complete military organization as in this country. All seamen should be familiar with the character of assistance rendered by the United States Coast Guard, a work in which it has been engaged for many years with pronounced success.

The commanding officer of a vessel of the Navy will occasionally find himself in a position to render assistance similar to that extended by Coast Guard vessels. The purpose of this chapter is to set forth briefly what may be termed the "doctrine" of the Coast Guard with respect to certain cases that may arise, and the methods that have been found successful by Coast Guard officers.

Calls for Assistance. Assistance to a vessel in trouble at sea is rendered by one or more cruising Cutters[2]; if the vessel is

[1] Commander H. G. Hamlett and Lieutenant Commander F. C. Billard.

[2] The cruising vessels of the Coast Guard, although of a size which places them in the Gunboat or Small Cruiser class when they act as a part of the Navy (in time of war), are technically designated as "Cutters."

stranded, help will be given by one or more Cutters and by the crew of the nearest Coast Guard station on shore; reenforced, when necessary, by the crews of adjacent stations.

A vessel in need of assistance should, if possible, send word of her predicament by radio to the nearest shore radio station, taking care to give the exact location of the vessel, her condition, and sufficient data concerning the weather so that the probable drift of the disabled craft may be estimated. *The conventional S.O.S. signal should be used only in emergent cases*, because all the available resources of the Coast Guard are immediately directed in response to an S.O.S. call, and misuse of this urgent distress signal may serve to divert the assisting Cutters from other assistance work which may be, in fact, more urgent. All radio calls for assistance reach the operating officers of the Coast Guard through the Coast Guard communication system and prompt action to afford assistance is taken, when the circumstances of the case warrant, to the utmost resources of the Service. Any change in conditions should be reported and, if it later develops that assistance is not needed, information to this effect should be immediately sent out. Cases have occurred where failure to cancel calls for assistance has resulted in a needless expenditure of fuel and time on the part of a Coast Guard Cutter. As it is the aim of the Coast Guard to answer all calls for assistance, it should be the part of mariners to cooperate by asking for assistance only when really necessary, by furnishing all possible information, by advising of changes in conditions as they occur, and by annulling the distress call when assistance is no longer needed.

Doctrine. The doctrine herein set forth is that which governs officers in command of Coast Guard Cutters, and is recommended for the guidance of the Commanding Officers of naval vessels in similar circumstances. In what follows, the term "Commanding Officer" refers to the officer in command of a United States naval vessel or Coast Guard Cutter; the word "master" means the captain in charge of a merchant vessel.

The case of a vessel in distress will usually involve either:

(*a*) Rescuing the crew from a ship in danger of foundering,
(*b*) Taking a disabled vessel in tow,
(*c*) Floating a stranded vessel.

In connection with the prevention of disasters to vessels,

there is the work of (*d*) removing or destroying floating menaces to navigation.

The Master of a vessel in distress at sea is responsible for the safety of the lives and property in his charge. Whether all or any of the people are to be taken off the vessel is a matter for him to decide. It is highly desirable, when a vessel is taken in tow in such condition that she is apt to founder, that all the personnel be taken off except only those absolutely necessary to handle the vessel; so that, should the vessel suddenly sink, the number of lives jeopardized may be reduced to a minimum. Whether or not the people are to be taken off is to be decided by the Master of the disabled vessel; the *manner* of taking them off is decided by the Commanding Officer of the public vessel assisting. The matter of rescuing property and personal effects is entirely in the hands of the Commanding Officer of the assisting vessel. In general, it is the function of the Commanding Officer to advise the Master of the distressed ship in the premises. If the master accept the advice tendered, the conduct of the operation lies solely with the Commanding Officer.

When a vessel is taken in tow, the question of *destination* often arises in connection with facilities for repairs, character of cargo, and other matters. The governing factor should be to get the vessel to the most practicable place of safety, taking into consideration the resources of the assisting vessel, the conditions of wind and sea, and any other circumstances; acceding, however, to the wishes of the Master in so far as is practicable, in the judgment of the Commanding Officer. It is the right of the Master to let go the tow line whenever he sees fit. Often, when a tow is nearing a place of safety, a commercial tow boat may come alongside and apply for the job of taking the disabled craft into port. In such cases it is the doctrine of the Coast Guard that it is not its function to interfere in any way with private enterprise. The Commanding Officer should see that the bargain proposed is fair and reasonable. If such be the case, in his opinion, he should let go the tow. Naturally, the Commanding Officer who possibly has picked up the tow under trying circumstances and has towed her successfully under great difficulties, feels a strong desire to complete the job by delivering his charge into a safe harbor. It must be borne in mind, however, that the rights of private enterprise which maintains facilities for doing work of this character at large expense must

be respected, and that the duty of the public vessel terminates when the element of danger to the ship and her people is removed.

The line of demarcation between the duties of the Commanding Officer of a public vessel and the right of private marine enterprise becomes more difficult to ascertain in the case of a stranded vessel. When danger to life is involved, it is, of course, the paramount duty of the public vessel to do everything possible to save life, regardless of any other question.

Suppose a vessel ashore is fallen in with, no other help in sight and no danger to life imminent. When communication has been established, the Commanding Officer proffers his advice based upon his experience in similar circumstances, having in mind that the responsibility for the welfare of the stranded vessel and for whatever operations are to be undertaken, if any at all, rests with the Master. It may be that the vessel is ashore among rocks and to pull her off might result in serious injury to her bottom, with possible danger of sinking in deep water. The Master of the ship must decide whether or not an effort shall be made to pull the vessel off at the time. It will generally be found that the Master of the stranded craft will follow the advice of the Commanding Officer of the public vessel there to assist him; so that it is very important that the advice given be based upon a careful study of the situation in all its aspects, having in mind that the actual decision must be made by the Master himself, as the responsibility is his, and his alone.

It may be that before passing a line to the stranded vessel a commercial wrecking vessel or tug arrives upon the scene. The duty of the Commanding Officer is first to permit negotiations between the tug and the Master of the stranded ship for floating the ship. The general principle is that the public vessel must make every effort to save the stranded craft, and at the same time not interfere with private enterprise. If the facilities offered by the tug are manifestly inadequate, the Commanding Officer would be justified in counselling the master of the stranded vessel to make no bargain except for the tug to *assist* the efforts of the public vessel. If, on the other hand, the facilities of the tug are reasonably adequate for the task, and reasonable terms are proposed, then the duty of the Commanding Officer is to notify the Master of the stranded ship that the public vessel will not engage in the operations to the exclusion of the tug, but will assist as may be required.

The Coast Guard does not ordinarily undertake assistance work involving extensive wrecking operations or lightering. Its services in behalf of vessels in distress are rendered regardless of the nationality of the vessel assisted. Under the law, United States vessels may render aid and assistance to any vessel wrecked, disabled or in distress in the waters of Canada contiguous to the United States; and Canadian vessels may render aid and assistance to any vessel wrecked, disabled, or in distress in the waters of the United States contiguous to the Dominion of Canada.

Derelicts. In general, the removal of sunken obstructions or dangers to navigation *within the navigable waters of the United States* devolves by law upon the Secretary of War. The destruction or removal of wrecks, derelicts and other floating dangers to navigation *beyond the navigable waters of the United States* devolves primarily upon the Coast Guard by law. This is construed to include also the removal or destruction of sunken obstructions outside the navigable waters of the United States. Under the terms of an international convention, dated January 20, 1914, the United States and the leading maritime nations of Europe undertook to take all steps to insure the destruction of derelicts in the northern part of the Atlantic Ocean east of a line drawn from Cape Sable to a point situated in latitude 34 degrees North and longitude 70 degrees West. They also agreed to establish in the North Atlantic a service for the study and observation of ice conditions and a service of ice patrol. The Government of the United States was invited to undertake the management of the three services of derelict destruction, study and observation of ice conditions, and ice patrol, and the President designated the Coast Guard to carry out this work.

While the Coast Guard is especially charged with the destruction or removal of obstructions to navigation outside the three-mile limit, it is obviously the duty of the Commanding Officer of a naval vessel, if no Coast Guard vessel be available, upon falling in with an obstruction constituting a menace to navigation, to take appropriate action in the case.

Derelicts and other floating dangers to navigation, wherever found, should be taken to the most convenient port whenever practicable. When it is not practicable to take a derelict or other floating danger into port, it should be destroyed or beached, care being exercised in each case that such destruction does not

leave sunken or floating wreckage of such size or character as to constitute a menace to passing ships. If the derelict or other floating danger is to be destroyed within the navigable waters of the United States and the emergencies of the case permit, the Army Engineer Officer in charge of the district should be communicated with and consulted before final action is taken. Whenever circumstances make it necessary to destroy a derelict or other floating danger to navigation before consulting the Engineer Officer of the district, within the navigable waters of the United States, the Commanding Officer should promptly notify that officer.

When knowledge is obtained of any sunken obstruction to navigation within the navigable waters of the United States, Commanding Officers should promptly notify the District Engineer Officer and take no further action unless requested by that officer. The Commanding Officer should see that a wreck is properly buoyed or lighted before he leaves it. He should in all cases where wrecks are buoyed and lighted by him notify the nearest Lighthouse Superintendent of the fact, giving full information as to the character of the buoy or light established, and forwarding, if practicable, a section of the chart showing its position in order that such information may be published in the weekly Notice to Mariners.

A derelict may be fallen in with which is evidently of very considerable value. It then becomes necessary to decide whether an effort shall be made to tow the derelict into port or whether it shall be destroyed. If the duty upon which the public vessel is employed permits and the towing facilities are adequate, and the weather conditions promising, an effort should be made to tow the abandoned vessel into port. On the other hand, it may be that the derelict is directly in the path of commerce; it may be, for example, in the trans-Atlantic steamship lanes; weather conditions may be such that a considerable period will probably elapse before it can be taken in tow, with further danger that contact will be lost. In such a case, the Commanding Officer would be justified in promptly destroying the derelict regardless of any consideration other than the safety of lives that might be jeopardized by collision between passing vessels and the derelict. The Commanding Officer should weigh carefully the matter before deciding to destroy what would be, if salvaged, very valuable property. But if, in his judgment, the

possibility of jeopardizing lives by collision with the derelict outweighs the consideration of property value alone, he should not hesitate to sink the derelict. A floating derelict in the frequented paths of commerce is one of the greatest menaces to safety at sea, and the decision of a Commanding Officer on the spot to destroy such a menace is not open to question. The salvage of floating wreckage is not usually attempted, and such obstructions are ordinarily mined and destroyed.

When a derelict vessel is towed into port, it should be turned over to the custody of the owner if practicable; otherwise, to that of the United States Marshal.

Rescuing the Crew from a Ship in Danger of Foundering. This subject is covered in Chapter XXVI and the practice of the Coast Guard is in accord with the general principles therein set forth. Usually, on a Coast Guard Cutter, two of the boats are surf boats, carried on davits in the waist, one on each side, equipped for lowering and hoisting and for work in rough water. In the waist is the logical place to carry such boats on a small ship because there is less pitch, the ship's rail is apt to be lower there, the boat is clear of the propeller, it gets the advantage of the lee formed by the forward or the after part of the ship, and generally a boat can be handled better along the straight part of the side of the ship and will be less liable to be stove as the ship rolls than if under the counter or the bluff of the bow. Also, on a small ship, the operation of lowering, hooking on and hoisting is directly under observation from the bridge, as it should be; particularly when getting the boat away or picking it up in a seaway.

The boat should never be lowered until the order to lower is given from the bridge, and great care should be taken to give the order at the most favorable time.

Obviously, the nearer the ship can be brought, with safety, to the wreck, the easier the task for the boat's crew and the less the danger to them. By careful manœuvring and watching the drift, it will be found that a vessel can be held much nearer to a drifting craft than would be thought feasible, particularly if held with her stern clear in a position to increase distance when imperative.

In the equipment of a life-boat carried at davits, it is advisable to have coarse mesh nets, readily made on board from small stuff, stopped along the rail between the davits, and deep enough when

dropped to reach down to the boat on the high roll of the ship. The boat's crew and passengers can come up or go down such a net more quickly and with greater safety than they can make their way up or down sea ladders. Such a net is particularly useful when hooking on a boat in a bad sea, when, of course, it is most desirable to lighten the boat of her crew as soon as possible.

Taking a Disabled Vessel in Tow at Sea. The Coast Guard practice in picking up a tow at sea is usually to get a line to the tow by heaving line or by the use of a shoulder gun, placing the cutter in the most advantageous position in accordance with the principles laid down in Chapter XXV. In good weather it is generally unnecessary to use a boat and in bad weather it is seldom practicable.

When other conditions permit, it will generally be found handier in the case of a vessel having a single right hand propeller to work under the starboard bow of a vessel for the reason that backing shapes up your own ship for going clear; whereas, while under the port bow, backing shapes up your ship for fouling. It is always well to keep fifteen or twenty fathoms of your end of the hawser so that the nip may be easily fleeted by slacking away. Moreover, it will often be possible to ease the strain on a hawser, and still maintain good speed, by slacking away several fathoms and bringing the vessels in step. Whenever it is necessary to slack or veer a hawser, always stop your ship; if you do not take this precaution the hawser is liable to take charge of things. *Never make a hawser fast so that it cannot be let go or cut away instantly.* This precaution is often overlooked, particularly when towing with wire.

A hawser should be protected from chafe as much as possible. This applies to wire as well as to manila. With a vessel in tow, always slow down when about to make a pronounced change in course to avoid parting the line when the catenary snaps out of water and brings a sudden strain on the towing gear.

In picking up a sailing vessel underway, remember that she is making good a course several points to leeward of her heading.

When heaving in a hawser that has parted or been let go, keep way on your ship, heading up to windward if practicable, to avoid fouling the propeller. *Whenever you have a line of any kind over your stern, keep constantly in mind the possible danger of fouling the propeller.*

A ship with disabled steering gear can sometimes be best handled by making fast astern of her. The disabled vessel can then do the towing and the assisting ship can do the steering by sheering across the former's stern as necessary.

A ship which yaws badly under tow on account of being down by the head may often be towed comfortably stern first. A drag over the stern of a ship being towed and yawing badly will generally relieve the yawing.

A change in speed or in course or both will often relieve dangerous strain on a towing hawser.

Floating a Stranded Vessel. This subject is discussed in Chapter XXVIII. The assisting vessel should feel her way in carefully, taking into consideration the stage of the tide and state of the sea. Remember that on a sandy beach a bar will often form outside of a large stranded ship. Every effort should be made to anchor in just the right position to pull most effectively, having in mind the way the current will probably set while lines are being run and while hauling on the stranded vessel.

The best time to pull is, of course, at high water. If you begin to pull a few minutes before high water and continue to pull with full power until twenty or thirty minutes after high water—in a locality where there is considerable rise and fall of the tide—without results, it is almost useless to continue to pull on the vessel; it is better to wait until the next high water.

With a line leading from a forward chock, use a "dipping rope" or bridle to keep the line away from your propeller.

It will be of very great assistance if, while pulling on the stranded vessel, another vessel is at hand to hold up the head of your ship against the set of the current. You will thus be enabled to pull along the direction best calculated to obtain the desired result.

When conditions permit, "jumping" on the line by getting a little slack on the hawser and then going ahead full speed will sometimes start a stranded ship. This, however, always involves danger of parting the hawser or of doing other damage.

At night, it is a good idea for the stranded vessel to use a search light kept trained along her own keel line so that the assisting vessel will know at all times just how she is lying.

When a *small* vessel is ashore on a sandy beach and the sand has formed around her, a length of 2-inch pipe screwed on to a deck hose may be useful. Pumping water through the pipe may

force away the sand sufficiently to enable the vessel to be floated. This has been successfully accomplished.

The Removal of Derelicts. To locate a derelict that has been reported by a passing steamer is often no easy matter. The success of the search depends upon a number of elements,—the accuracy of the original report, the time elapsed since the derelict was seen, the weather and currents. With such information as he has received, the Commanding Officer of a vessel ordered to find the derelict must use his best judgment in estimating the probable drift of the derelict since it was last reported. A systematic search should be planned and carried out in accordance with accepted methods (search curves) designed to cover to the best advantage, during daylight, the area in which the derelict may be expected to be found, giving due weight to conditions of weather and sea. In actual practice, it is rarely that a derelict is found without a protracted search.

The derelict when found should either be destroyed or taken in tow. The wrecking mines used for destroying derelicts are of the standard Navy type. The number of mines used and the manner of connecting them up will depend upon circumstances.

In order to get the best results, the mines should be *in actual contact* with the objects to be destroyed; this is often a difficult task and is sometimes impossible. To blow up a hull, particularly if it is waterlogged, the best method is to place the mines inside so that the explosive effect will rend the parts asunder. Or they may be placed under the hull, being held in place by hogging lines. The efficient use of wrecking mines to destroy derelicts and wreckage at sea calls for good judgment, considerable ingenuity and some former experience in the work, and is not devoid of danger.

To take a derelict in tow is apt to prove a slow and arduous task. It will often be difficult to find a suitable means of making fast a towing hawser on the derelict; as, for example, on a hull floating bottom up. No two cases will be found exactly alike, and an officer must depend largely upon his resourcefulness and ingenuity to solve the problem presented.

Coast Guard Stations.

The sea and lake coasts of the United States, exclusive of the coast of Alaska, have an extent of more than 10,000 miles. There are to-day upon these coasts 273 active Coast Guard

stations, 180 of which are on the shores of the Atlantic, 9 on the shores of the Gulf of Mexico, 21 on the shores of the Pacific, and 62 on the shores of the Great Lakes. These stations are located at selected points of danger to shipping and vary somewhat in character, according to their environment and the nature of the service demanded of them. On some portions of the coast they are placed only at long intervals, while upon others they form chains of contiguous posts within communicating distance of each other.

The **equipment** of Coast Guard stations consists of the beach apparatus—line-projecting guns, hawsers, breeches buoys, etc.—flag and pyrotechnic signals, heaving sticks and lines, life preservers, life cars, and lifeboats, surfboats, and other types of boats.

The outfits are practically the same at all the stations, but the boats are of various types, depending upon their suitability for rescue work on the different coasts. The lifeboats are too heavy to be launched from the beach into the surf, and launching ways are provided and located for them where comparatively smooth water prevails—on rivers, bays, and inlets. The surfboats are launched into the surf without the aid of launching ways.

Types of Boats.—Boats used in the Coast Guard may be divided into two general classes—those driven by gasoline motors and those without motive power other than sails or oars. They are further subdivided as to their hull construction into three classes: open boats, self-bailing boats, and self-righting and self-bailing boats. (See Chapter IX and Plates **61** and **62**.)

Line-carrying Guns, etc.—For effecting line communication with stranded vessels and between cutters and disabled vessels in heavy weather the Coast Guard chiefly employs the Lyle gun, but other types may of course be used (Plate **185**).

For a vehicle in which to transport people from a wreck to shore after line communication has been established, the breeches buoy is generally used. The life car is sometimes taken, however, especially where many persons are to be landed and where the distance is too great to use the breeches buoy. The car is a covered boat, made of corrugated galvanized iron, furnished with rings at each end, into which hauling lines are bent, whereby the car is hauled back and forth on the water between the wreck and the shore without the use of any apparatus. It is supplied, however, with bails, one near each end, by which it can be

suspended from a hawser and passed along upon it like the breeches buoy if found necessary, as is sometimes the case where the shore is abrupt. The cover of the boat is convex, and is provided with a hatch, which fastens either inside or outside, through which entrance and exit are effected. Near each end it is perforated with a group of small holes, like the holes in a grater, punched outward, to supply air for breathing, without admitting much, if any, water. It is capable of containing six or seven persons, and is very useful in landing sick people and valuables, as they are protected from getting wet. On the first occasion of its use it saved 201 persons. (Plate **186.**)

At Coast Guard stations a fixed beat or patrol is laid out in each direction along the shore, varying, according to the conformation of the coast with respect to inlets, headlands, etc., from one-half to 2, 3, or 4 miles in length. The station crew is divided into regular watches of two men each, who during the hours from sunset to sunrise, patrol these beats, keeping a sharp lookout seaward at all times.

At sunset the first man starts out on patrol in the same direction from all stations in a district, so far as practicable. While the patrolman is out, his watchmate takes the station watch, which is kept in the tower or on the beach abreast the station, as conditions may require. If the station is connected with the service telephone line, the station watch makes it his business to be within hearing distance of the bell at regular intervals. In addition to keeping watch seaward, he is on the lookout for signals and telephone calls from the patrolman. Upon the return of the first patrol, he takes the station watch and the other man patrols in the opposite direction. At the proper time the man on station watch calls out the next two men, who must be dressed and ready for duty before the first two turn in.

This routine is varied to meet local conditions. In harbors and seaports fixed lookouts are usually maintained instead of a beach patrol.

In some cases telephones are located in halfway houses or at the ends of the patrols; in such cases the patrolmen report to their stations by telephone. In other cases the patrolman is provided with a small hand telephone set with which he can communicate with the station.

Each patrolman carries a number of red Coston signals with which to warn a vessel standing too close inshore or to notify a vessel in distress that he has gone to summon assistance.

The same system of patrols is kept up in thick and foggy weather.

It should be stated that the beach patrol is an institution of distinctly American origin. It was devised by the former Life-Saving Service and inaugurated in that service about 1870–75.

To insure that the crews of wrecked vessels shall understand what to do when station crews are making rescues by means of the beach apparatus gear, two tally boards or tablets are used. One of these is spliced permanently into the tail of the whip block just above the splice, and the other is spliced or bent on the top end of the hawser. Each tally board contains inscriptions, in English on one side and in French on the other, telling explicitly what is to be done after they are received.

INSTRUCTIONS TO MARINERS IN CASE OF SHIPWRECK.

All sea-faring people should be familiar with the following instructions, which are practically identical with those issued by all nations having Life Saving Services. It is the unanimous testimony of the personnel of such services that the principal difficulties with which they have to deal arise from the failure of shipwrecked crews to cooperate intelligently in the work of rescue.

INSTRUCTIONS.

Rescue with the Life-Boat or Surf-Boat.

The patrolman, after discovering your vessel ashore and burning a Coston signal, hastens to his station for assistance. If the use of a boat is practicable, either the large life-boat is launched from its ways in the station and proceeds to the wreck by water, or the lighter surf-boat is hauled overland to a point opposite the wreck and launched, as circumstances may require.

Upon the boat reaching your vessel, the directions and orders of the Warrant Officer in charge (who always commands and steers the boat) should be implicitly obeyed. Any headlong rushing and crowding should be prevented, and the captain of the vessel should remain on board, to preserve order, until every other person has left.

Women, children, helpless persons, and passengers should be passed into the boat first.

Goods or baggage will positively not be taken into the boat until all are landed. If any be passed in against the warrant officer's remonstrance he is fully authorized to throw the same overboard.

Rescue with the Breeches-Buoy or Life-Car. (Plate **186.**)

Should it be inexpedient to use either the life-boat or surf-boat, recourse will be had to the wreck-gun and beach apparatus for the rescue by the breeches-buoy or the life-car.

A shot with a small line attached will be fired across your vessel.

Get hold of the line as soon as possible and haul on board until you get a tail-block with a whip or endless line rove through it. This tail-block should be hauled on board as quickly as possible to prevent the whip drifting off with the set or fouling with wreckage, etc. Therefore, if you have been driven into the rigging, where but one or two men can work to advantage, cut the shot-line and run it through some available block, such as the throat or peak-halliards block, or any block which will afford a clear lead, or even between the ratlines, that as many as possible may assist in hauling.

Attached to the tail-block will be a tally-board with the following directions in English on one side and French on the other:

"Make the tail of the block fast to the lower mast, well up. If the masts are gone, then to the best place you can find. Cast off shot-line, see that the rope in the block runs free, and show signal to the shore."

The above instructions being complied with, the result will be as shown in Fig. 1, Plate **186.**

As soon as your signal is seen a three-inch hawser will be bent on to the whip and hauled off to your ship by the life-saving crew.

If circumstances will admit, you can assist the life-saving crew by manning that part of the whip to which the hawser is bent and hauling with them.

When the end of the hawser is got on board a tally-board will be found attached, bearing the following directions in English on one side and French on the other:

"Make this hawser fast about two feet above the tail-block, see all clear and that the rope in the block runs free, and show signal to the shore."

These instructions being obeyed, the result will be as shown in Fig. 2, Plate **186.**

Take particular care that there are no turns of the whip-line round the hawser. To prevent this take the end of the hawser UP BETWEEN *the parts of the whip before making it fast.*

When the hawser is made fast, the whip cast off from the hawser, and your signal seen by the life-saving crew, they will haul the hawser taut and by means of the whip will haul off to your ship a breeches-buoy suspended from a traveler-block, or a life-car from rings, running on the hawser.

Fig. 3, Plate **186,** represents the apparatus rigged, with the breeches-buoy hauled off to the ship.

If the breeches-buoy be sent, let one man immediately get into it, thrusting his legs through the breeches. If the life-car, remove the hatch, place as many persons into it as it will hold (four to six), and secure the hatch on the outside by the hatch-bar and hook, signal as before, and the buoy or car will be hauled ashore. This will be repeated until all are landed. On the last trip of the life-car the hatch must be secured by the inside hatch-bar.

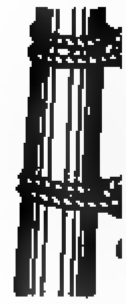
In many instances two men can be landed in the breeches-buoy at the same time by each putting a leg through a leg of the breeches and holding on to the lifts of the buoy.

Children, when brought ashore by the buoy, should be in the arms of older persons or securely lashed to the buoy. Women and children should be landed first.

In signaling as directed in the foregoing instructions, if in the daytime, let one man separate himself from the rest and swing his hat, a handkerchief, or his hand; if at night, the showing of a light, and concealing it once or twice, will be understood; and like signals will be made from the shore.

Circumstances may arise, owing to the strength of the current or set, or the danger of the wreck breaking up immediately, when it would be impossible to send off the hawser. In such a case a breeches-buoy or life-car will be hauled off instead by the whip, or sent off to you by the shot-line, and you will be hauled ashore through the surf.

Plate No. 186.



HAWS

Bree

Life Ca

RESCUING PASSENGERS FROM STRANDED VESSEL.

If your vessel is stranded during the night and discovered by the patrolman, which you will know by his burning a brilliant red light, keep a bright lookout for signs of the arrival of the life-saving crew abreast of your vessel.

From one to four hours may intervene between the burning of the light and their arrival, as the patrolman will have to return to his station, perhaps three or four miles distant, and the life-saving crew draw the apparatus or surf-boat through the sand or over bad roads to where your vessel is stranded.

Lights on the beach will indicate their arrival, and the sound of cannon-firing from the shore may be taken as evidence that a line has been fired across your vessel. Therefore, upon hearing the cannon, make strict search aloft, fore and aft, for the shot-line, for it is almost certain to be there. Though the movements of the life-saving crew may not be perceptible to you, owing to the darkness, your ship will be a good mark for the men experienced in the use of the wreck-gun, and the first shot seldom fails.

RECAPITULATION.

Remain by the wreck until assistance arrives from the shore, unless your vessel shows signs of immediately breaking up.

If not discovered immediately by the patrol, burn rockets, flare-up, or other lights, or, if the weather be foggy, fire guns.

Take particular care that there are no turns of the whip-line round the hawser before making the hawser fast.

Send the women, children, helpless persons, and passengers ashore first.

Make yourself thoroughly familiar with these instructions, and remember that on your coolness and strict attention to them will greatly depend the chances of success in bringing you and your people safely to land.

The following signals, approved by the International Marine Conference convened at Washington in October, 1889, have been adopted by the United States Coast Guard, and will be used and recognized by the officers and men as occasion may require:

"Upon the discovery of a wreck by night, the life-saving force will burn a red pyrotechnic light or a red rocket to signify—'You are seen; assistance will be given as soon as possible.'

"A red flag waved on shore by day, or a red light, red rocket, or red Roman candle displayed by night, will signify—'Haul away.'

"A white flag waved on shore by day, or a white light slowly swung back and forth, or a white rocket, or white Roman candle fired by night will signify—'Slack away.'

"Two flags, a white and a red, waved at the same time on shore by day, or two lights, a white and a red, slowly swung at the same time, or a blue pyrotechnic light burned by night, will signify—'Do not attempt to land in your own boats. It is impossible.'

"A man on shore beckoning by day, or two torches burning near together by night, will signify—'This is the best place to land.'

"Any of these signals may be answered from the vessel as follows: In the daytime, by waving a flag, a handkerchief, a hat, or even the hand; at night, by firing a rocket, a blue-light, or a gun, or by showing a light over the ship's gunwale for a short time, and then concealing it."

APPENDIX.

§ I. SAILING SHIPS.

Although sails and spars have practically disappeared from the navy and from the experience of the average seafaring man even in the merchant service, they are far from having disappeared from the ocean; and some familiarity with them may still be expected on the part of every seaman who aspires to be even tolerably well informed in his profession.

Plates **187, 188,** and **193** show the various rigs which are commonly seen in deep-sea vessels.

A **ship,** often referred to as "a full-rigged ship," has three masts; the fore, main, and mizzen, all of them square-rigged.

A ship may have more than three masts. Four-masted ships are common, and five-masters are occasionally seen. In a four-master the after-mast is called the jigger-mast. In a five-master, the masts are usually called "fore," "main," "middle," "mizzen," and "jigger."

A **Barque** has three masts, the fore and main square-rigged, the mizzen, fore-and-aft rigged.

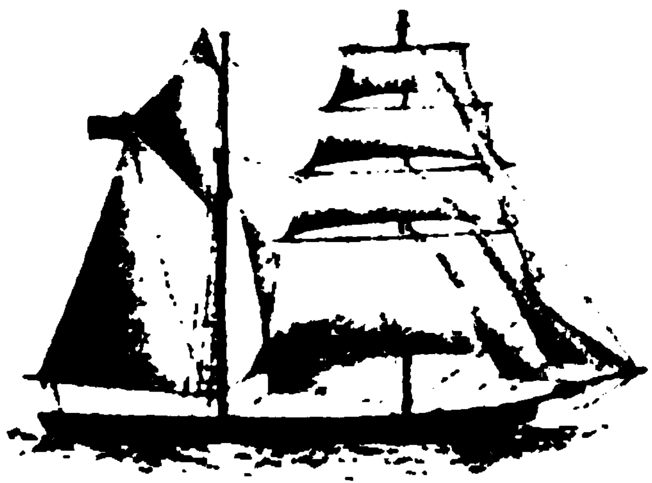
A barque, like a ship, may have more than three masts, the names being the same as in the case of a ship. She is still a barque if all the masts except the after one are square-rigged.

A **Barkentine** has three or more masts, of which the two after ones, main, and mizzen, or mizzen and jigger, are fore-and-aft rigged. A five-master, with the three after-masts fore-and-aft rigged is still a barkentine.

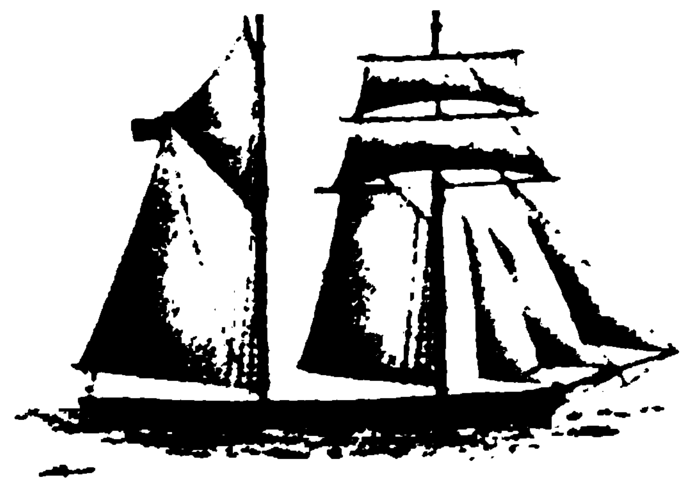
A **Brig** has two masts, both full square-rigged. A brigantine is a brig without a square mainsail; that is to say, she carries all the square sails of a brig on both fore and main masts, except the mainsail.

A **Hermaphrodite Brig** has two masts, the foremast full square-rigged, the mainmast full fore-and-aft rigged. A hermaphrodite brig is often incorrectly called a brigantine.

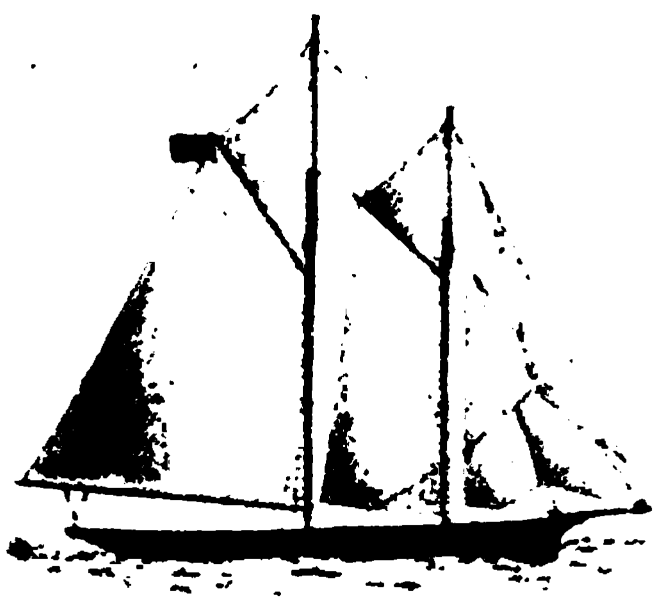
A **Topsail Schooner** has a fore-and-aft foresail, with a square



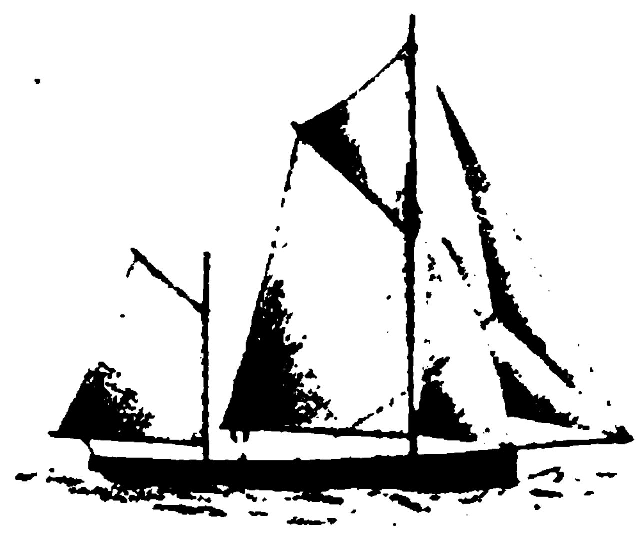
HERMAPHRODITE BRIG.



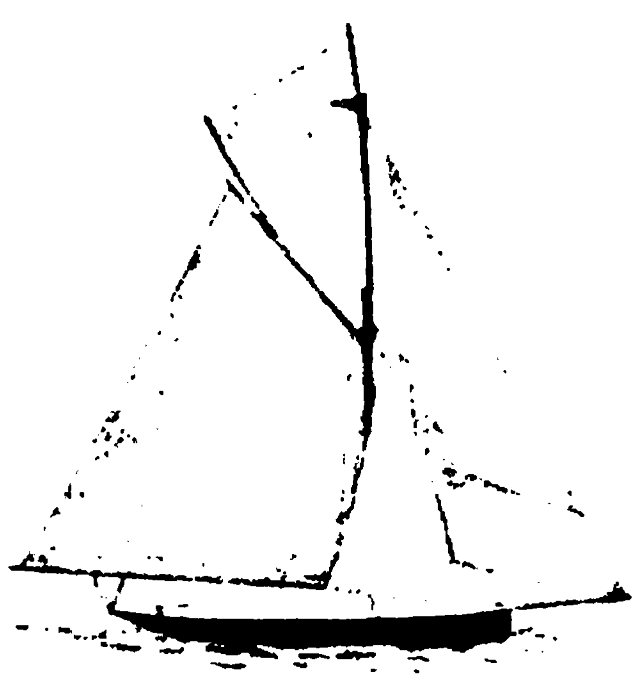
TOPSAIL SCHOONER.



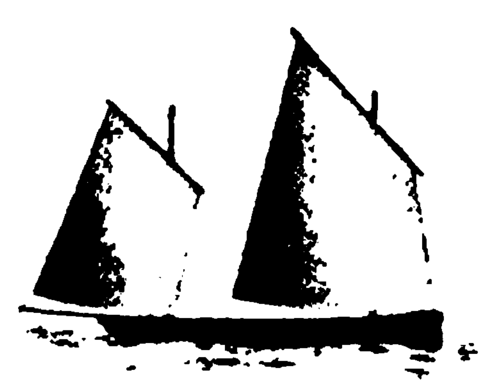
SCHOONER
may have as many as five
masts



KETCH.
YAWL, same as KETCH but
with a smaller mizzen
abaft the tiller.



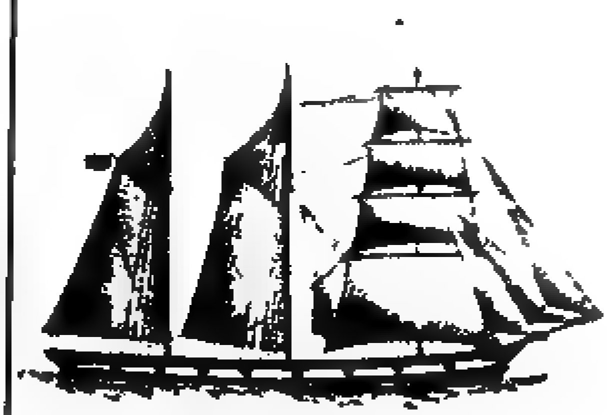
CUTTER.



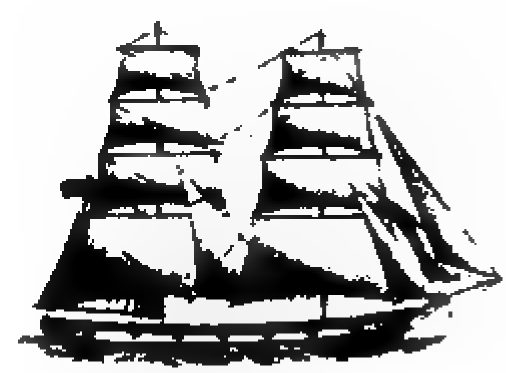
LUGGER

SAILING CRAFT.

FULL RIGGED SHIP



BARQUENTINE



BRIG.

BRIGANTINE same as BRIG, but without a square mainsail

BARQUE.

SAILING CRAFT.

fore-topsail, and in some cases a fore-topgallant sail. The main-mast is full fore-and-aft rigged. A topsail schooner is often incorrectly called a hermaphrodite brig.

A **Schooner** has two, three, or more masts, all fore-and-aft rigged. The designations of the masts where there are more than two are the same as in the case of a ship or a barque.

There are many variations in the single-masted rig shown in the **Cutter** of Plate **187.** The " sloop " differs from the cutter so far as rig is concerned in having a short fixed bowsprit instead of a long moveable one, and in carrying only one head sail. The most important distinction, however, between the sloop and the cutter, as at present recognized by yachtsmen, has to do with the model of the hull rather than with the rig.

The **Ketch** and the **Yawl** are modifications of the single-master rather than of the schooner, since they have grown out of the desire to make the total sail area more manageable by dividing it. For racing, the " single-sticker " holds its own because, as is well known, a given amount of canvas has far greater *driving* power in one sail than in two. An incidental advantage of the yawl or ketch rig is that the craft can be handled under very small sail—jib and jigger—which is a great convenience in working around a harbor, and may be of vital consequence in bad weather when the mainsail must be lowered, perhaps only for reefing; a situation in which the boat under a jib alone would be altogether unmanageable, and reefing a difficult and dangerous operation.

The same considerations of manageability with a small crew which have led to the development of the yawl and ketch from the single-master, have led to the division of the mainsail of large schooners, resulting in the production of schooners of three, four, and more masts.

Details of Rigging—Square-Riggers.

Masts. Lower masts in modern ships are usually built up of steel plates stiffened in various ways by steel shapes.

Built-up masts of wood are no longer used, although lower masts made of single pine sticks are not uncommon in sailing ships of moderate size.

Topmasts and topgallant-masts are still made of wood, usually of pine.

The mast rests on a step, placed as low as possible; usually on the keelson. At the lower end is a *tenon* fitting into a *mortise* at the step. Where the mast passes through the successive decks, timbers are built in from beam to beam, forming *partners;* the space between these and the mast being filled by tightly fitting wedges.

The masthead is smaller than the body of the mast, and at the shoulder, called the *hounds,* where the reduction in size is made, heavy knees or *bibbs,* are bolted on, widening the shoulder and forming a secure support for the *trestle-trees;* stout fore-and-aft pieces which, in their turn, support the *cross-trees,* the *top,* the *topmast,* and the eyes of the lower rigging. The cross-trees are athwartship pieces crossing the trestle-trees forward and abaft the masthead, and forming the principal part of the framing of the top. They are jogged down into the trestle-trees, and with the latter form a skeleton to which the comparatively light planking of the top is secured.

The lower masthead terminates in a square tenon, to which the *cap* is fitted. This may be of wood, iron-bound, or built up of steel.

The topmast passes through a round hole in the forward part of the cap, which thus binds the two masts together. In the heel of the mast is a thwartship hole, square in section, through which is placed an iron *fid,* with its ends projecting and resting on the trestle-trees on either side. Two sheaves placed diagonally in the heel of the topmast furnish a lead for the top pendants, by which the mast is sent up and down. The over-lapping parts of the lower masts and topmasts are the *doublings.*

The topmast head is fitted in practically the same way as the lower masthead, and the heel of the topgallant-mast "doubles" upon it similarly. Cross-trees are used here as spreaders for the topgallant rigging, but without a top.

FOUR-MASTED SHIP UNDER SAIL.

1 Foresail	12 Upper jigger topsail	29 Spanker
2 Mainsail	13 Fore topgallant sail	30 Buntlines
3 Crossjack	14 Main topgallant sail	31 Leechlines
4 Jigger	15 Mizzen topgallant sail	32 Reeftackles
5 Lower fore topsail	16 Jigger topgallant sail	33 Braces
6 Lower main topsail	17, 18, 19, 20, Royals	34 Foresheet
7 Lower mizzen topsail	21, 22, 23, 24, Skysails	35 Fore topmast staysail sheet
8 Lower jigger topsail	25 Flying-jib	36 Jib-sheet
9 Upper fore topsail	26 Outer-jib	37 Outer jib-sheet
10 Upper main topsail	27 Jib	38 Flying jib-sheet
11 Upper mizzen topsail	28 Fore topmast staysail	

KEY TO PLATE 188

1 Foremast
2 Mainmast
3 Mizzenmast
4 Topmasts; fore, main and mizzen.
5 Topgallant masts; fore, main and mizzen.
6 Royal and skysail masts; fore, main and mizzen.
7 Fore yard
8 Main yard
9 Crossjack yard
10 Lower topsail yards; fore, main and mizzen.
11 Upper topsail yards; fore, main and mizzen.
12 Lower topgallant yards; fore, main and mizzen.
13 Upper topgallant yards; fore, main and mizzen.
14 Royal yards; fore, main and mizzen.
15 Skysail yards; fore, main and mizzen.
16 Spanker gaff
17 Trysail gaff, fore and main
18 Lower shrouds
19 Topmast shrouds
20 Back stays
21 Fore skysail stay
22 Fore royal stay
23 Flying-jib stay
24 Fore topgallant stay
25 Jib stay
26 Fore topmast stays
27 Fore stays
28 Main skysail stay
29 Main topgallant stay
30 Main topmast stay
31 Mizzen skysail stay
32 Fore and main lifts
33 Topsail lifts
34 Topgallant lifts
35 Spanker boom
36 Bowsprit
37 Jib-boom
38 Flying jib-boom
39 Martingale or dolphin striker
40 Braces (named from yard to which they belong)
41 Bobstays
42 Martingale guys

KEY TO PLATE 189

Plate No. 189.

Standing and Running Rigging.

Topgallant and royal masts are in one, but the diameter is reduced at the topgallant masthead forming *hounds,* upon which rests the topgallant *funnel;*—a composition cylinder, with two thwartship arms forming the "*Jack.*" At the royal masthead is a similar shoulder, with an iron band for the rigging, and above this is the *pole* terminating in a tenon to which the *truck* is fitted. The truck usually carries the point of a lightning conductor, the lower end of which makes contact with the hull, or, in the case of a wooden ship, with the copper well below the water-line.

Trysail masts are fitted up and down abaft the lower masts, being stepped on deck and secured at the head by bands connecting by a key to corresponding bands on the lower mast.

Modern men-of-war rarely carry sail, and such masts as they have are usually for military purposes only;—in some cases for carrying light guns in elevated positions, in other cases merely for signalling.

Yards. A full-rigged ship carries a lower, topsail, topgallant, royal, and sometimes a sky-sail, yard, on each mast. The topsail is usually double (Plates **188, 189**).

Standing Rigging. The masts of a ship are supported from the sides by *shrouds,* from forward by *stays* and from aft by *backstays.* The *backstays* contribute also to the sidewise support since they are necessarily led to the sides of the ship. The *stays,* in addition to supporting the masts, serve to carry certain fore-and-aft sails known as *staysails.* For convenience in hooking tackles at the mastheads for various purposes, heavy *pendants* are provided, fitted with thimbles and links and hanging well clear of the other rigging. Small lines, called "ratlines," stretched from shroud to shroud, furnish the means of going aloft.

The head-booms are supported from beneath, against the pull of the stays and the lifting tendency of the head sails, by *bobstays, martingales,* etc., leading to the cut-water; and from the sides by *bowsprit shrouds, jib-* and *flying jib-guys,* leading to the bow.

The above constitute the "Standing Rigging" of a ship.

Standing Rigging is usually fitted of galvanized steel-wire rope, plain-laid, of six strands, and is protected from the weather,

Fore Mast and Head-Booms of a Modern Sailing Ship.

chafe and wear, by a thorough covering of worming, parcelling and serving (Plate 25).

Sails. Sails are made of canvas, which may be of flax, hemp or cotton. The sails of ships are always of flax, those of boats and small yachts usually of cotton. Cotton canvas is used also on ship-board for a variety of purposes, such as awnings, windsails, hammocks, tarpaulins, etc.

Canvas is manufactured in long strips or *cloths,* varying in width from 16 to 24 inches for flax, and from 20 to 42 inches for cotton, and in lengths of from 40 to 80 yards. The cloths are made up in rolls called *bolts.*

Variations in weight, strength and fineness are indicated by numbers running from 1 to 10; number 1 being the heaviest, strongest and coarsest, and number 10 the lightest and finest.

In the United States Navy, canvas is used as follows:

For the sails of ships, flax canvas, 24 inches wide, issued in bolts of 80 yards. For awnings, screens, etc., cotton canvas, 22 inches wide, in bolts of 90 yards. For hammocks and bags, cotton canvas, 42 inches wide, in bolts of 90 yards. For boats' sails, cotton canvas of the variety known as "raven's duck," 28½ inches wide, in bolts of 65 yards.

Good canvas is made of long, strong, clean threads, evenly spun and well twisted and without any mixture of tow. In the heavier grades (Nos. 1 to 3), the threads are double, and in all grades the cloths should be closely and uniformly woven, and with a firm, even selvage. To test a sample of canvas, after examining carefully the character of the texture as to the smoothness and closeness of the weaving, it is well to bore through with a fid, when the threads will break easily if of inferior quality, and resist, with a disposition to stretch before yielding altogether, if of good strong staple. A few threads may be drawn and examined as to length, smoothness and freedom from tow; and finally, if two samples are to be compared, similar strips from the two may be knotted together and tested by hanging weights from them to determine which is the stronger.

An 80-yard bolt of No. 1 flax canvas, 20 inches wide, should weigh about 75 lbs. and the successive numbers from this to No. 10 should diminish by about 5 lbs. each, a bolt of No. 2 weighing 70 lbs., one of No. 3, 65 lbs., and so on.

The following numbers are commonly used for the sails of a full-powered sailing ship, the lighter grades specified in each

case forming a fair-weather suit of sails, while the heavier ones are bent in anticipation of a stormy passage:

Courses,	Nos. 1 to 3.
Topsails,	" 2 to 3.
Topgallant sails,	" 4 to 5.
Royals,	" 5 to 6.
Topmast staysails,	" 3 to 4.
Jibs,	" 4 to 5.
Other staysails,	" 4 to 5.
Spankers, trysails, etc.,	" 4 to 5.
All storm sails,	No. 1.

The square sails of a ship (Plates **187** and **188**) are the *courses* (foresail and mainsail), the *topsails, topgallant sails* and *royals.* A *skysail* is sometimes set above the royals. Topsails and topgallant sails may be single or double.

The fore-and-aft sails are the fore-and-main *trysails,* the *spanker* (which is in reality a mizzen trysail), the *staysails,* taking their names from the stays on which they are set, and the *jibs,* which are also staysails, although not so-called. The trysails are called also *spencers,* and the spanker is often called the *driver.*

The upper edge of a square sail is called the *head,* the lower edge, the *foot,* the sides, *leeches,* the upper corners the *head cringles,* the lower corners, the *clews.*

In the case of a four-sided fore-and-aft sail like a trysail or spanker (Plate **192**) the after edge is the *after leech,* the forward edge the *luff,* the upper edge the *head,* the lower edge the *foot,* the upper after corner the *peak,* the upper forward corner the *nock,* the lower forward corner the *tack,* the lower after corner the *clew.*

In a triangular sail (Plate **192**), the edge next the stay is the *luff,* the after edge the *leech,* the lower edge the *foot,* the lower forward corner the *tack,* the lower after corner the *clew,* and the upper corner the *head.*

The details of sails of various kinds are fully shown in Plates **187, 191,** and **192.**

The cutting and making of sails constitute an art in themselves, which it would be beyond the province of this book to attempt to teach. The canvas must be cut with care, not only to economize material in adapting the narrow cloths to the irregular shapes required, but to reduce stretching to a minimum and to distribute

Plate No. 191.

Fore Mast and Head-Booms of a Modern Sailing Ship, Sails Set.

such stretch as cannot be prevented, in a way to avoid distorting the sail and allowing it to bag. Canvas stretches very little along the line of the threads of either warp or filling, but may give considerably under a diagonal pull. Owing to the way in which sails are set (being hauled out by their corners), the greater part of the strain to which they are subjected is diagonal, and one of the most difficult points in sail making is to arrange the material in such a way that the cloths may take this strain directly along the threads. When this has been done as far as possible, allowance must be made for the stretch which still remains, and also for the difference in stretching between the canvas and the roping.

The cloths are sewed together with overlapping (double) seams having from 110 to 130 stitches to the yard. The twine used should be of good flax or cotton, spun with from three to eight threads and waxed with pure beeswax.

Sails are reinforced at points which are subject to especial strain or chafe.

The edges of the sail all around are turned over, forming a hem or *tabling* several inches wide. The linings and other strengthening pieces are then sewed on, and lastly the *bolt-rope.* This is of hemp and should be of the best quality, rather loosely laid up to make it soft and pliable, and tarred with the best Stockholm tar. As there is more stretch to the rope than to the canvas, care must be taken to leave a little slack canvas along the edges, as otherwise the canvas, instead of the roping, would take the strain when the sail is set. A common rule is to allow one inch of slack canvas for every foot along the leeches of topsails and canvas, and one inch for every yard along the foot.

The roping of square sails is always on the after side of the sails, that of fore-and-aft sails usually on the port side.

Double Topsails and Topgallant Sails. Modern sailing ships almost without exception have double topsail yards and in many cases double topgallant yards as well. This rig was first proposed by an American shipmaster named Howe, and its many advantages were promptly recognized (Plates **187** and **191**).

In this rig, the lower topsail yard is fixed, while the upper yard hoists and lowers, the sail having half the depth of a single topsail. The lower (topsail) yard is trussed to the main cap, and the upper yard, when lowered, lies close above it. Thus by lowering the upper topsail, sail is reduced in a moment to the area

of an old-fashioned topsail when close-reefed, the upper topsail, when lowered, hanging forward of the lower topsail, where it is to a great extent becalmed.

Downhaul tackles are fitted from the yard-arms of the upper to those of the lower (topsail) yards to haul the yards down. This takes the place of "clewing-down" with a single topsail. The downhauls also support the lower topsail yard-arms, for which, usually, no lifts are fitted.

The lower topsail is fitted with sheets and clew-lines like an old-fashioned topsail, but as the leech is short, the clew-line blocks are placed well out on the yard. As a rule, the clews of the upper topsail shackle permanently to the lower topsail yard-arms.

Running Gear. The ropes, purchases, etc., by which the yards and sails are controlled constitute the Running Gear of the ship. Most of this gear is shown so clearly on the plates herewith, that a detailed description of their lead is unnecessary.

Halliards. Yards are hoisted by purchases consisting usually of a pendant, called a tye, and a purchase called the halliards.

The halliards of a staysail are bent to the head of the sail, lead up along the stay to a block at the masthead and thence on deck. For heavy sails, the halliards are double, and reeve through the blocks at the head of the sail, the standing part being made fast aloft and the hauling part leading as before.

The gaffs of trysails are supported by spans from the lower mast to the throat and peak, and when necessary may be hoisted and lowered by *throat* and *peak* halliards (Plate **192**).

Lifts. Yards are supported at the yard-arms by lifts, leading through blocks or fair-leaders at the masthead and thence to the top or the deck.

Braces. Yards are controlled as to their horizontal movement by *braces* leading from the yard-arms aft or forward. They are always led aft if circumstances permit this without requiring too much of a downward lead. In three-masted ships, the braces of yards on the fore-and-main are led aft, those of yards on the mizzen, forward.

Sheets. The clews of square sails are hauled out to the yards below them by sheets, reeving through sheaves in the yard-arms, thence through quarter-blocks under the yard and so to the deck.

Staysail and trysail sheets consist of pendants and whips, and are usually double, each sail having its port and starboard sheet.

Single Topsail.

Spanker.

DETAILS OF SAILS.

In the case of a sail hauling out to a boom, the purchase for controlling the boom is the "sheet" and the sail is hauled out by an "outhaul."

Tacks. To control the clews of the *courses,* not only sheets, but *tacks,* are needed, the tack hauling the weather clew down and forward, the sheet hauling the lee clew down and aft. The forward lower corner of a fore-and-aft sail is called the "tack," as is also the rope by which this corner is held down and secured.

Clew-lines. In taking in the sails, the clews are hauled up to the quarters of the yard by clew-lines leading from the clews to the quarter-blocks and down on deck. For topsails and courses the clew-lines are double, and reeve through a block at the clew, the standing part being clinched around the quarters of the yard.

Clew-lines or clew-ropes are fitted to trysails for hauling the clew up to the jaws of the gaff, and on gaff topsails for hauling the clew up to the head.

Leech-lines are used to haul the leeches of courses and sometimes of topsails along the yard.

Buntlines. Buntlines haul the foot of the sail above and forward of the yard for convenience in furling. They are rove through blocks at the masthead or the top rim, lead down forward and toggle to the foot of the sail some distance outside the midship line on each side.

Reef-tackles. Reef-tackles are whips leading from the yardarms of topsails and courses to cringle on the leeches of the sails, for hauling the leech up and out in reefing, affording slack for passing the earing and rousing the cringle up to its place.

Bowlines. Bowlines lead forward from the bowline bridles on the leeches of courses and topsails, and are used, when sailing on the wind, for hauling the leech well forward so that it shall hold the wind.

Outhauls. The head of a trysail is hauled out by a head outhaul, reeving through a sheave in the end of the gaff and a block at the mast, and then to the deck. The foot of a boomsail is hauled out by a foot-outhaul reeving through a sheave in the boom.

Downhauls. Staysails are hauled down by downhauls leading from the head of the sail along the stay to a block at the tack of the sail.

The head of a trysail is hauled down by a head downhaul from the head of the sail to the jaws of the gaff.

SCHOONER UNDER SAIL.

Brails. Gaff sails—trysails, spankers, etc.—are gathered in to the mast for furling, by brails middled and stopped to the after leech, with a hauling part on each side reeving through a block on the mast at a point corresponding to the point at which they are stopped to the leech.

Vangs. Vangs are fitted to gaffs at the after end—one on each side—and led to the ship's side. Their office is to steady the gaff *when the sail is not set.*

Details of Rigging—Fore-and-Aft Rigs.

Plate **193** shows the sails and rigging of a two-masted schooner. There are many variations from this rig, especially in yachting, where special sails are used in racing and to some extent in cruising, under favorable conditions of weather. The **gaff topsail** is often replaced by a "**club-topsail,**" having the head and foot stretched out by long light spars which admit of spreading a greatly increased area of canvas. In this case the halliards are bent to the "yard" on the head of the sail near the middle point, and the yard, when hoisted to the masthead, carries the peak of the sail well up, playing the part of a topmast "pole."

A **balloon-jib** is a very large triangular sail extending from the fore-topmast head to the jib-boom end. As it has no stay, it is set "flying."

A **jib-topsail** sets on the fore-topmast stay and corresponds to the flying-jib of an ordinary schooner.

A **spinnaker** is a very large, very light triangular balloon-like sail, often made of raw silk, used in running free. The head goes to the mast-head—either fore or main—and the foot hauls out to a "**spinnaker-boom,**" temporarily rigged out on the side opposite the main-boom.

Where the spinnaker, instead of being triangular in shape, is quadrilateral, its head, always very short, hauls out on a temporary gaff rigged out for the masthead, the foot hauling out as in other cases to the spinnaker-boom. In this case the sail is called a "**shadow.**"

Various other sails—of questionable utility—are set at times by racing yachts. Such are "**water sails**" under the spinnaker boom; "**ring-tails**" increasing the area of the mainsail, etc.

The ordinary main topmast staysail is often replaced by a very large sail of the same general type as the spinnaker and the balloon jib.

§ II. TONNAGE OF SHIPS.

As there is sometimes confusion as to the difference between displacement and the several kinds of tonnage, the following definitions are given.

Displacement. The quantity or volume of water displaced by a ship is called her "displacement"; it can be expressed in either cubic feet or tons; a cubic foot of sea-water weighs 64 lbs. and of fresh water 62.5 lbs., therefore a ton is equal to 35 cubic feet of sea-water or 35.9 cubic feet of fresh water.

Tonnage, Gross Register. The total enclosed space or internal capacity of a ship, *expressed in tons of 100 cu. ft. each,* is the gross register tonnage. The unit of volume is that figure which was used originally in "Moorsom's System" of measuring ships, which system has, with slight variations in application, been adopted by most of the nations of the civilized world.

Gross register tonnage is used as a basis for calculating net register tonnage and in the United States as a basis for dry dock charges for steamers.

Tonnage, Net Register. The actual earning power of a ship is expressed by the net register tonnage and this figure is secured by deducting from the gross tonnage such spaces as may have no earning capacity; for instance, the engine, boiler and shaft alley spaces, coal bunkers, spaces used in steering and working the ship, and such spaces as may be necessary for the accommodation of the crew. The laws of the several nations vary with reference to the various deductible spaces. The Suez Canal Tonnage, although based upon the "Moorsom System," and generally similar to net register tonnage, varies therefrom in some respects.

The rules and laws which have been, from time to time, enacted in the several countries, are extensive and complicated, but are usually published in some form. For reference the following are cited:

English.—Instructions Relating to the Measurement of Ships. Issued by Board of Trade.

United States.—Navigation Laws of the U. S. Bureau of Navigation, Department of Commerce and Labor.

Suez Canal.—Reglement de Navigation dans le Canal Maritime de Suez. Suez Company.

Net register tonnage is generally used in charging harbor and port dues, canal tolls, and other similar charges to which merchant ships are liable.

§ III. SHIP'S PUMPS AND THEIR USES.

1. **Main Air Pump.** Used for pumping the air and condensed steam from the condenser into the feed-tank and thus maintaining a vacuum in the condenser. In merchant practice and some of the older naval vessels, this pump is direct-connected to the main engine.

2. **Main Circulating Pump.** Used for circulating sea water through the condenser, and is usually of the centrifugal type. It has an independent sea-suction valve called the main injection and also a suction connection with the bilge called the bilge injection. It has a discharge through the main condenser and thence overboard through a valve called the outboard delivery. It has also a discharge leading directly from the pump overboard so that the bilge water can be pumped overboard without sending it through the condenser. Since a centrifugal pump will throw ashes, waste, etc., without clogging and also since the capacity of the circulating pump of a ship is generally far greater than the aggregate capacity of all the other bilge pumps, the circulating pumps are of great use in case a large volume of water gets into the ship from any cause. The number of circulating pumps varies according to the number of condensers.

3. **Main Feed Pump.** This is used for feeding the boilers and has suctions from the main feed tanks and reserve feed tanks, and but one delivery to the main feed line. There are one or more of these pumps according to the power and arrangement of the machinery and boilers, and located either in the engine-room or fire-room according to circumstances and the views of the designers. These pumps in merchant practice are sometimes direct connected to the main engines.

4. **Auxiliary Feed Pump.** This is designed primarily to be used when the main feed pump is out of repair. It can draw from the main feed tank and reserve tank, and from the bottom of the main condenser (in which case it takes the place of the air pump). It can deliver either into the boilers through the auxiliary feed line or into the reserve feed tanks. The number of auxiliary feed pumps varies as in the case of main feed pumps:—there is generally one in each fire-room.

5. **Main Fire and Bilge Pump.** The principal use of this pump, as its name indicates, is for the fire and bilge service. It has an independent sea suction and delivery. At sea it is kept going

slowly and continuously to keep the bilges free, and in this case other pumps are used for fire service if they are capable of supplying a sufficient quantity of water. When it becomes necessary to use the bilge pump for fire service, or for washing decks, the pump should always first be washed out by pumping sea water overboard, otherwise greasy waste and coal dust may be spread over the deck. This pump is also connected with the main and secondary drains so as to pump out the bilges or double bottom compartments of the ship. The number of these pumps varies with the size of the ship and the arrangement of the engine compartments. Such pumps are sometimes placed outside of the engine compartments and are sometimes called "wrecking" pumps.

6. **The Auxiliary Air and Circulating Pump.** This is generally a combined pump formed of two water cylinders and one steam cylinder. One of the water ends takes sea water direct from the sea and circulates it through the auxiliary condenser overboard. The other end draws fresh water from the bottom of the auxiliary condenser and delivers it into the feed tank. There are generally two auxiliary condensers, each with one combined air and circulating pump. Combined air and circulating pumps will not be used in future designs, on account of their extravagant use of steam.

7. **The Water-Service Pump.** This is a small pump used to produce a forced circulation of water through the crosshead slides and the main journals of the main engines, when the natural circulation due to the distance of the engines below the water-line is not sufficient for the purpose. It is convenient to have a connection by which this pump can deliver into the fire main, and also, into the distiller in case the distiller circulating pump should be out of repair. There is generally one such pump in each engine compartment.

8. **The Distiller Circulating Pump.** Is used for circulating cooling water from the sea through the distillers and thence directly overboard. It usually has, however, suitable connections by which the water can be delivered into the flushing system instead of overboard and also the water can be delivered into that system without passing through the distiller if the latter should be disconnected for repair.

9. **The Fresh-Water Pump.** Is for drawing off the fresh water

from the distiller and delivering it into the ship's tanks when the distiller is situated at a lower level than the tanks.

10. **The Flushing Pump.** Is used for circulating sea water through the flushing system. It often has a connection so that it can be used to circulate water through the distiller when the distiller pump is under repair. The pipes composing the flushing system are usually distinct from the fire main, but sometimes the fire main is used as part of the flushing system on a small ship.

11. **The Evaporator Feed Pump.** Is a small light-service pump for supplying salt water to the evaporators. It has a suction from the sea, and, in new designs, from the evaporator feed heaters. Its discharge is to the evaporators.

12. Special pumps, such as brine-circulating pumps and water-circulating pumps are provided for the refrigerating plant, and recent large battleships are also provided with special motor-driven pumps for draining the fire-rooms.

§ IV. PERMITTED DRAFT OF SHIPS. PLIMSOLL MARK.

The Plimsoll Mark is the mark painted on the sides of a ship at the middle of her length on the water-line, to indicate the drafts at which, for various conditions and types or classes of cargo-carrying vessels there will still be left a sufficient percentage of reserve buoyancy to insure the safety of the vessel. The position of this mark depends upon the type and size of the vessel. On it are indicated the maximum safe drafts for fresh and salt water, for winter and summer, and for certain oceans.

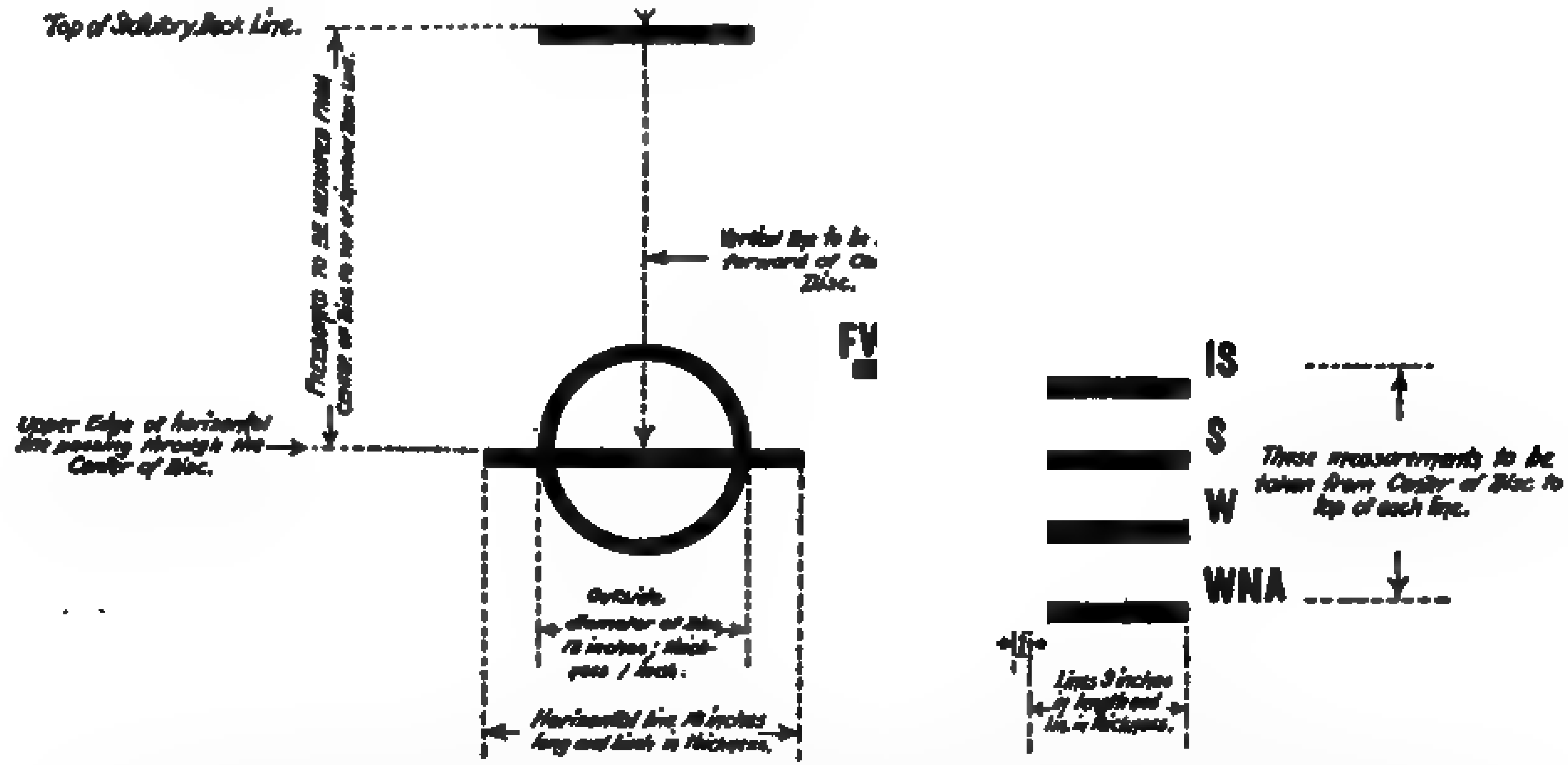
Explanation of Symbols on the Plimsoll Mark.

FW = Fresh Water.
IS = Indian Ocean in Summer.
WNA = North Atlantic in Winter (October to March inclusive).
S = Summer in waters other than the Indian Ocean.
W = Winter in waters other than the North Atlantic.

All except the first of the above symbols indicate the maximum depth in salt water for the corresponding oceans and seasons.

THE MODE OF MARKING, APPROVED BY THE BOARD OF TRADE (BRITISH), IS AS FOLLOWS:

FREEBOARD MARKING FOR STEAMERS.



The center of disc to be placed on both sides of vessel amidships, i. e., at the middle of the length of the load water line. Vessels are to be marked with such of the horizontal lines as are applicable to the nature of their employment In accordance with the regulations made by the Board of Trade, the discs and the lines must be permanently marked by center punch marks or by cutting, and the particulars given in the certificate are to be entered in the official log.

§ V. DETAILS OF U. S. NAVY BOATS.

DIMENSIONS, HORSE-POWER, CAPACITY AND WEIGHTS OF BOATS AND OUTFITS

Type of Boat.	Principal Dimensions. Length. ft.	ins.	Extreme breadth to outside of planking. ft.	ins.	Depth from top of gunwale to lower edge of garboard amidships. ft.	ins.	Hp.	Carrying capacity. Men.	Approximate Weight in Pounds. Hull and machinery complete.	Fuel.	Lubricating oil.	Water In boiler and feed tanks.	+ Stores Provisions.	+ Stores Water.	Outfit ± Not part of hull	Men in boat when hoisted. No.	Wt.	Total hoisting weight.
Steamer	50	—	9	9½	6	2½	170	44	36,389	3,440	37	2,080	80	175	1,108	4	600	43,904
"	40	—	8	10½	5	2½	50	29	20,317	2,900	37	1,900	57	133	1,022	4	600	26,966
"	30	—	8	—	4	9½	25	26	11,226	1,162	37	1,235	50	60	356	4	600	14,865
Motor boat	50	—	10	2	5	4	150	50	17,525	1,015	50	......	100	210	500	4	600	20,000
" "	35	—	8	7½	4	6½	100	27	9,050	525	37	......	46	133	498	3	450	10,737
Motor barge	40	—	9	6	4	11½	150	37	12,900	959	37	......	57	133	550	3	450	15,066
Motor boat	26	—	6	6	3	2½	20	18	3,087	162	37	......	34	80	100	2	300	3,800
Motor dory	21	—	5	9½	2	4	5	10	1,900	300	......	......	23	41	329	2	300	2,893
Motor-sailing launch	50	—	12	11	5	3½	20	190	22,281	600	37	......	333	800	1,767	4	600	26,438
" "	40	—	10	10	4	3½	20	90	11,235	600	37	......	161	400	1,058	4	600	14,091
" "	36	—	9	9½	3	9	15	70	9,697	600	37	......	126	333	1,036	4	600	12,429
" "	33	—	9	4	3	7½	10	50	7,436	375	37	......	92	266	1,025	2	300	9,530
" "	30	—	8	7½	3	6½	10	40	6,823	375	37	......	69	200	822	2	300	8,626
" "	24	—	7	1½	2	11½	10	19	4,968	375	37	......	34	83	443	2	300	6,230
Cutter	30	—	8	—	2	10	......	40	2,498	......	......	......	69	175	662	2	300	3,704
"	28	—	7	5	2	8	......	33	2,430	......	......	......	57	133	579	2	300	3,517
"	26	—	6	11	2	6	......	27	2,045	......	......	......	45	108	573	2	300	3,081
"	24	—	6	6	2	6	......	19	1,660	......	......	......	34	83	568	2	300	2,645
Racing Cutter	31	—	......	......	......	......	......	18	1,373	......	......	......	34	66	385	2	300	2,158
Whaleboat	30	—	8	2½	2	10½	......	40	2,796	......	......	......	69	175	748	14	2,100	5,888
"	28	—	7	8½	2	8	......	32	2,405	......	......	......	57	133	670	14	2,100	5,365
"	24	—	6	9½	2	5½	......	23	1,875	......	......	......	46	108	607	7	1,050	3,686
"	20	—	5	11	2	4½	......	16	1,243	......	......	......	34	83	545	6	900	2,805
Dinghy	20	—	5	6	2	1½	......	14	930	......	......	......	23	83	365	1	150	1,551
"	16	—	4	7	1	10½	......	10	423	......	......	......	23	41	331	1	150	968
Wherry	14	—	4	4½	1	7½	......	5	370	......	......	......	11	25	240	1	150	796
"	12	—	4	4½	1	6½	......	4	260	......	......	......	11	25	222	1	150	668
Punt	14	—	6	½	1	8 15/16	......	......	606	......	......	......	......	......	75	1	150	831
"	12	—	4	2	1	8	......	......	495	......	......	......	......	......	75	1	150	720
"	10	—	3	7	1	5½	......	......	413	......	......	......	......	......	75	1	150	638

The 50-ft. and 30-ft. steamers are no longer standard. They will be replaced as rapidly as possible by the 50-ft. and 36-ft. motor boats respectively.
A s[illegible] has been developed and adopted for Destroyers and Gunboats.
For [illegible], see Plates 65, 66, 67.

§ VI. ROPE, U. S. NAVY.

MANILA ROPE, PLAIN LAID.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
6 thread, ¾ inch......	0.12	250	30	700	Note that sizes from 3 inch down are only made in 3 strands. Note that sizes from 3¼ inch up are only made in 4 strands, unless specially ordered of 3 strands. Special sizes may be made up on order of the bureau. Any size needed can be manufactured, but not in longer lengths than 150 fathoms. Note that rope up to 4 inch is made on machines which do not require the walk, and such rope may be made in any length, the finished coil not to exceed 1,100 pounds in weight for rope 3 inches circumference and above, nor to exceed 300 pounds in weight for rope 1¼ to 2¾ inches circumference, inclusive.
9 thread, 1 inch......	.20	150	30	1,100	
12 thread, 1⅛ inch....	.25	120	30	1,500	
15 thread, 1¼ inch....	.30	100	30	1,800	
18 thread, 1⅜ inch....	.35	150	52	2,000	
21 thread, 1½ inch....	.50	200	100	2,500	
1¾-inch..............	.60	200	120	3,000	
2-inch...............	.83	200	167	4,000	
2¼ inch..............	1.00	200	204	5,000	
2½-inch..............	1.26	150	190	5,550	
2¾ inch..............	1.55	150	225	6,600	
3-inch...............	1.83	150	277	7,800	
3¼-inch..............	2.16	150	325	9,200	
3½-inch..............	2.54	150	380	10,500	
3¾-inch..............	2.80	150	420	12,200	
4-inch...............	3.25	150	487	13,700	
4¼-inch..............	3.66	150	550	14,900	
4½-inch..............	4.00	150	600	17,400	
4¾ inch..............	4.40	150	660	19,000	
5-inch...............	5.00	150	750	21,800	
5¼-inch..............	5.50	150	825	23,700	
5½-inch..............	6.00	150	900	27,700	
6-inch...............	7.24	150	1,087	31,000	
6½-inch..............	8.43	150	1,275	33,500	
7-inch...............	9.80	150	1,470	36,200	
7½-inch..............	11.20	150	1,680	42,300	
8-inch...............	13.00	150	1,950	47,300	
8½-inch..............	14.40	150	2,160	54,200	
9-inch...............	16.20	150	2,430	60,000	
9½-inch..............	18.00	150	2,700	67,000	
10-inch..............	20.00	150	3,000	74,200	

MANILA HEMP, PLAIN LAID, HAWSERS.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
5-inch...............	5.33	120	640	21,800	These may be made in any size, but not in longer lengths than 150 fathoms, the length of the ropewalk. The strands are hauled a little longer and the rope closed up with more afterturn, making it a little fuller than plain laid rope of the same size. These hawsers are hauled out longer than 120 fathoms to allow for fag ends, which are not cut off, and for a splice which is not made, but the weight is charged to 120 fathoms, making it heavier than plain laid rope of same size.
6-inch...............	7.90	120	950	31,000	
7-inch...............	10.40	120	1,250	36,200	
8-inch...............	13.30	120	1,600	47,300	
9-inch...............	17.20	120	2,060	60,000	
10-inch..............	22.16	120	2,660	74,200	

American Hemp Rope, Tarred, Plain Laid, Three Strand.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
[illegible]-inch.	0 31	200	62	[illegible]0	Note that this may be made to any size if required. It is, however, seldom or never called for in larger sizes.
1-inch.	.36	200	72	1,[illegible]0	
1¼-inch.	.40	200	80	1,[illegible]0	
1½-inch.	.50	200	100	2,[illegible]0	
1¾.	.63	200	126	3,[illegible]5	
2-inch.	.96	200	192	3,[illegible]5	
2¼.	1.28	200	256	4,[illegible]8	
2½-inch.	1.56	150	235	5[illegible]0	
2¾-inch.	1.90	150	285	7,[illegible]0	
3-inch.	2.24	150	336	8,[illegible]0	
3¼-inch.	2.66	150	400	9[illegible]0	
3½-inch.	3.06	150	460	11[illegible]0	
3¾-inch.	3 53	150	530	13[illegible]0	
4-inch.	4.00	150	600	14[illegible]0	

Ratline Stuff and Similar Material Made up on Special Orders of Tarred American Hemp.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
6-thread, ¾-inch	0.18	100	18	650	
9-thread, 1-inch	.25	100	25	1,120	
12-thread, 1¼-inch	.35	100	35	1,500	
15-thread, 1⅜-inch	.45	100	45	1,800	
18-thread, 1½ inch	.53	100	53	2,100	
21-thread, 1⅝-inch	.60	100	60	2,400	
24-thread, 1¾-inch	.70	100	70	2,650	

American Hemp, Tarred, Bolt Rope.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
1-inch.	0 27	100	27	120	
1¼-inch.	.37	100	37	780	
1½-inch.	53	100	53	470	
1¾-inch.	.70	100	70	500	
2-inch.	94	100	94	300	
2¼-inch.	1.18	100	118	550	
5½-inch.	1 50	100	150	790	
2¾-inch.	1.75	100	175	220	
3-inch.	2 11	100	211	800	
3¼-inch.	2.44	100	244	493	
3½-inch.	2 84	100	284	220	
3¾-inch.	3.33	100	333	300	
4-inch.	3 72	100	372	000	
4¼-inch.	4.25	100	425	600	
4½-inch.	4 74	100	474	050	
4¾-inch.	5.38	100	538	400	
5-inch.	6.00	100	600	900	

American Hemp Rope, Tarred, Plain Laid, Four-strand.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
1½-inch	0.60	200	120	1,800	Note that this rope is made up in four strands only on special orders.
1¾-inch	.77	200	155	2,490	
2-inch	.96	200	192	3,085	
2¼-inch	1.20	200	240	4,340	
2½-inch	1.60	150	240	5,250	
2¾-inch	1.90	150	285	6,352	
3-inch	2.20	150	330	7,560	
3¼-inch	2.70	150	405	8,870	
3½-inch	3.00	150	450	10,290	
3¾-inch	3.50	150	525	11,812	
4-inch	4.00	150	600	12,440	
4¼-inch	4.50	150	675	15,170	
4½-inch	5.00	150	750	17,010	
4¾-inch	5.70	150	855	18,952	
5-inch	6.40	150	960	21,000	
5¼-inch	7.00	150	1,050	23,152	
5½-inch	7.75	150	1,162	25,410	
5¾-inch	8.52	150	1,278	28,773	
6-inch	9.30	150	1,395	30,240	
6½-inch	10.75	150	1,612	35,532	
7-inch	12.30	150	1,845	40,202	
7½-inch	14.30	150	2,145	46,350	
8-inch	16.50	150	2,475	53,172	
8½-inch	19.00	150	2,850	60,480	
9-inch	21.00	150	3,150	67,040	

Seizing Stuff—Tarred American Hemp.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
4-thread, ½-inch	0.095	100	50	365	5 lengths to package.
6-thread, ¾-inch	.12	100	50	560	4 lengths to package.
9 thread, ⅞-inch	.165	100	50	700	3 lengths to package.
12-thread, 1-inch	.21	100	60	955	3 lengths to package.

Lead Lines.

Name and circumference.	Material.	Weight per fathom.	Length of coil.	Weight of coil.
		Pounds.	*Fms.*	*Pounds.*
Boat lead line, ⅝-inch	Cotton twine, braided	0.07	25	1.75
Ship's lead line, ¾-inch	Flax twine, braided	.14	33⅓	4.67
Coasting lead line, 1-inch	....do	.18	100	18.00
Deep-sea lead line, 1½ inch	Am. hemp, plain laid	.47	150	70.50

Log Lines.

Name and circumference.	Material.	Weight per fathom.	Length of coil.	Weight of coil.
		Pounds.	*Fms.*	*Pounds.*
Chip log line, ¾-inch	American hemp	0.15	100	15.00
Taffrail log line, ¾-inch	Cotton twine, braided	.14	33⅓	4.67
Do	....do	.14	66⅔	9.34
Do	....do	.14	100	14.00

COTTON LINES.

Name and circumference.	Weight of coil.	Length of coil.	Weight per fathom.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	
[illegible]d, 8 ply, 1 [illegible]ch..	30	115	0 26	
[illegible]d, 8 ply, 1 [illegible]...	30	160	.19	
[illegible]d, 8 ply, [illegible]...	30	200	.154	
[illegible]d, 8 ply, [illegible]..	30	260	.11	
[illegible]d, 8 ply, [illegible]...	10	110	.09	Wound in 10-pound packages; 6 packages packed for shipment in bale weighing 60 pounds.
[illegible]d, 6 ply, [illegible]....	10	250	.04	
[illegible]d, 6 ply, [illegible]...	10	280	.035	
[illegible]d, 4 ply, [illegible]..	10	330	.03[1]	

[1] For clothes stops.

MISCELLANEOUS SMALL STUFF.

Cod line of untarred American hemp weighing 0.09 pound per fathom and made up in 10-pound coils, one of which suffices for 10 sets of hammock clews, this being the purpose for which this material is issued: 6 packages packed for shipment in bale weighing 60 pounds.

Untarred marline for sennit is made up in 10-pound coils, weight per fathom, 0.028 pound; six packages packed for shipment in bale weighing 60 pounds.

Yacht marline is tarred; is used for small work in rigging lofts; weight per fathom, 0.0195 pound; length of 60 fathoms; weight, 1.17 pounds; coil, 20 pounds, or as required.

Marline tarred.—Weight per fathom, 0.0327 pound; lengths of 65 fathoms; weight, 2.125 pounds; coil, 20 pounds, or as required.

House line. Weight per fathom, 0.0519 pound; lengths of 65 fathoms; weight, 3.375 pounds; coil, 20 pounds, or as required.

Round line. Weight per fathom, 0.066 pound; lengths of 60 fathoms; weight, 4 pounds; coil, 50 pounds, or as required.

Spun Yarn, 2-yarn. Weight per fathom, 0.528 pound; length of 65 fathoms; weight, 3.437 pounds; coil, 50 pounds, or as required.

Spun Yarn, 3-yarn. Weight per fathom, 0.073 pound; lengths of 65 fathoms; weight 4.75 pounds; coil, 50 pounds, or as required.

MANILA ROPE.

Manila rope to be of the grade known to the trade as "Rope made of selected yarns,", viz. yarn to be spun of long-fiber manila hemp of a grade not inferior to the mark SB/CS or of selected fiber equal to that mark.

Rope from ¾-inch circumference, 6-thread to 3 inches circumference, inclusive, to be made 3-strand; 3½ inches circumference and above to be made 4-strand unless otherwise specified. For the rapid handling of loads of about 900 pounds, such as coaling whips, a 4½-inch circumference manila rope is recommended.

WIRE ROPE.

For details of the construction, manufacture, and applications of Wire Rope, see Chapter III, IV and Plate 17.

Wire Rope—6 × 19—144 Wires.

Diam.	Approx. Circum.	Approx. Wt. per Fathom.	Ungalvanized. Average Breaking Strength.	Ungalvanized. Maximum Safe Working Load.	Galvanized. Average Breaking Strength.	Galvanized. Maximum Safe Working Load.	Min. Diameter of Sheave or Drum.
Inches.	*Inches.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Feet.*
1/4	3/4	0.6	6,300	1,134	5,770	1,035	1
5/16	1	0.9	9,000	1,620	8,100	1,458	1.25
3/8	1 1/8	1.32	13,500	2,430	11,150	2,007	1.50
7/16	1 1/4	1.8	18,800	3,384	16,920	3,042	1.75
1/2	1 1/2	2.34	24,200	4,356	21,780	3,915	2
9/16	1 3/4	3.00	29,000	5,220	26,100	4,725	2.25
5/8	2	3.72	38,000	6,840	34,200	6,156	2.5
3/4	2 1/4	5.34	52,600	9,468	47,340	8,514	3
13/16	2 1/2	6.00	60,000	10,800	54,000	9,720	3.25
7/8	2 3/4	7.2	70,000	12,600	63,000	11,340	3.5
1	3	9.48	90,000	16,200	81,000	14,580	4
1 1/16	3 1/4	11.00	100,000	18,000	90,000	16,200	4.25
1 1/8	3 1/2	12.00	112,000	20,160	100,800	18,090	4.5
1 3/16	3 3/4	13.1	124,000	22,140	111,600	20,520	4.75
1 1/4	4	14.3	138,000	25,200	124,200	22,320	5
1 3/8	4 1/4	18.0	168,000	30,600	151,200	27,180	5.5
1 7/16	4 1/2	19.6	180,000	32,400	162,000	29,160	5.75
1 1/2	4 3/4	21.3	196,000	36,000	176,400	31,680	6.0
1 5/8	5	24.9	220,000	39,600	198,000	35,640	6.5
1 3/4	5 1/2	29.1	266,000	48,600	239,400	43,020	7
1 7/8	5 3/4	33.3	300,000	54,000	270,000	48,600	8
2	6 1/4	37.8	332,000	59,400	298,800	53,730	8
2 1/4	7 1/8	48.0	420,000	75,600	378,000	68,040	9
2 1/2	7 7/8	59.1	526,000	95,400	473,400	85,140	10
2 3/4	8 5/8	71.7	630,000	113,400	567,000	102,060	11

The wire rope used by the United States Navy corresponds with that manufactured commercially, and the Tables which follow are those from the manufacturers' catalogues.

It should be noted, however, that a tolerance of 10 per cent. up or down is allowed by Naval specifications, so that the breaking strength given in the tables is to be regarded as an *average* not as a *minimum*. Accordingly, the safe working load as given in the Tables is 10 per cent. below that of the manufacturers' catalogues, to provide for a possible breaking strength of 10 per cent. below the average.

The grades of steel used are:

For 6 × 12 Type:

Crucible Cast Steel up to 1/2 inch diameter.

Plow Steel above 1/2 inch diameter.

All galvanized.

For 6 × 24 Type:

Plow Steel.

All galvanized.

For 6 × 19 Type:
Plow and Crucible Steel.
Galvanized and ungalvanized.
For 6 × 37 Type:
Plow and Crucible Steel.
Galvanized and ungalvanized.

WIRE ROPE—6 × 37—222 WIRES.

Diam.	Approx. Circum.	Approx. Wt. per Fathom.	Ungalvanized. Average Breaking Strength.	Ungalvanized. Maximum Safe Working Load.	Galvanized. Average Breaking Strength.	Galvanized. Maximum Safe Working Load.	Min. Diameter of Sheave or Drum.
Inches.	*Inches.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Feet.*
$\frac{3}{8}$	$1\frac{1}{8}$	1.32	10,600	1,908	9,540	1,710	1.0
$\frac{7}{16}$	$1\frac{1}{4}$	1.8	15,000	2,700	13,500	2,430	1.15
$\frac{1}{2}$	$1\frac{1}{2}$	2.34	19,500	3,510	17,550	3,150	1.33
$\frac{9}{16}$	$1\frac{3}{4}$	3.0	25,000	4,500	22,500	4,050	1.5
$\frac{5}{8}$	2	3.72	32,000	5,760	28,800	5,184	1.75
$\frac{3}{4}$	$2\frac{1}{4}$	5.34	46,000	8,280	41,400	7,452	1.85
$\frac{7}{8}$	$2\frac{3}{4}$	7.2	58,000	10,440	52,200	9,360	2.16
1	3	9.48	74,000	13,320	66,000	11,970	2.5
$1\frac{1}{8}$	$3\frac{1}{2}$	12.0	02,000	16,560	82,800	14,850	2.83
$1\frac{1}{4}$	4	14.7	116,000	20,880	104,400	18,720	3.2
$1\frac{3}{8}$	$4\frac{1}{4}$	18.0	142,000	25,560	127,800	22,950	3.5
$1\frac{1}{2}$	$4\frac{3}{4}$	21.3	168,000	30,240	151,200	27,180	3.75
$1\frac{5}{8}$	5	24.9	190,000	34,200	171,000	30,780	4.0
$1\frac{3}{4}$	$5\frac{1}{2}$	29.1	226,000	40,680	203,400	36,540	4.25
$1\frac{7}{8}$	$5\frac{3}{4}$	33.0	250,000	45,000	225,000	40,500	4.5
2	$6\frac{1}{4}$	37.8	274,000	49,320	246,600	44,370	4.75
$2\frac{1}{4}$	$7\frac{1}{8}$	48.0	368,000	66,240	331,200	59'580	5.0
$2\frac{1}{2}$	$7\frac{7}{8}$	59.1	450,000	81,000	405,000	72,900	5.5
$2\frac{3}{4}$	$8\frac{5}{8}$	71.7	556,000	100,080	500,400	90,000	6.0

Diam.	Approx. Circum.	Approx. Wt. per Fathom.	Galvanized. Average Breaking Strength.	Galvanized. Maximum Safe Working Load.
Inches.	*Inches.*	*Pounds.*	*Pounds.*	*Pounds.*
1/4	3/4	.42	3,200	576
5/16	1	.60	5,200	936
3/8	1 1/8	.84	7,200	1,296
7/16	1 1/4	1.20	10,000	1,800
1/2	1 1/2	1.56	13,200	2,276
9/16	1 3/4	1.98	16,600	2,988
5/8	2	2.52	19,800	3,564
3/4	2 1/4	3.54	30,200	5,400
13/16	2 1/2	4.08	34,600	6,210
7/8	2 3/4	4.80	39,200	7,020
1	3	6.3	52,000	9,360
1 1/16	3 1/4	7.08	58,400	10,440
1 1/8	3 1/2	7.98	65,000	11,700
1 3/16	3 3/4	8.82	71,200	12,780
1 1/4	4	9.78	80,000	14,400
1 3/8	4 1/4	12.0	92,000	16,560
1 7/16	4 1/2	13.0	103,600	18,630
1 1/2	4 3/4	14.16	104,600	18,810
1 5/8	5	16.56	128,000	23,040
1 11/16	5 1/4	17.64	136,000	24,480
1 3/4	5 1/2	19.38	145,400	26,100
1 13/16	5 3/4	20.52	157,000	28,260
1 7/8	6	23.0	168,000	30,240
2	6 1/4	25.2	199,000	35,910
2 1/16	6 1/2	26.58	210,000	37,800

WIRE ROPE—6 × 24—144 WIRES.

Diam.	Approx. Circum.	Approx. Wt. per Fathom.	Galvanized. Average Breaking Strength.	Galvanized. Maximum Safe Working Load.
Inches.	*Inches.*	*Pounds.*	*Pounds.*	*Pounds.*
3/4	2 1/4	4.68	37,600	6,768
13/16	2 1/2	5.4	45,000	8,100
7/8	2 3/4	6.3	51,400	9,252
1	3	8.28	66,600	11,988
1 1/16	3 1/4	9.24	74,000	13,320
1 1/8	3 1/2	10.5	82,200	14,796
1 3/16	3 3/4	11.58	93,000	16,740
1 1/4	4	12.9	103,400	18,612
1 3/8	4 1/4	15.72	122,400	22,032
1 7/16	4 1/2	17.52	136,000	24,480
1 1/2	4 3/4	18.6	150,600	27,090
1 5/8	5	21.78	173,200	31,140
1 11/16	5 1/4	23.16	188,000	33,840
1 3/4	5 1/2	25.44	206,200	37,080
1 13/16	5 3/4	26.88	218,000	39,240
1 7/8	6	30.54	232,800	41,850
2	6 1/4	33.06	261,000	46,980
2 1/16	6 1/2	34.86	276,000	49,680

§ VII. NOMENCLATURE OF DECKS.

1. The following nomenclature of decks shall be followed for United States naval vessels.

2. The highest deck extending from stem to stern shall be called the "main deck."

3. A partial deck above the main deck at the bow shall be called the "forecastle deck"; at the stern, "poop deck;" amidships, "upper deck."

4. The name "upper deck," instead of "forecastle deck" or "poop deck," shall be applied to a partial deck extending from the waist to either bow or stern.

5. A partial deck above the main, upper, forecastle, or poop deck and not extending to the side of the ship, shall be called the "superstructure deck."[1]

6. A complete deck below the main deck shall be called the "second deck." Where there are two or more complete decks below the main deck they shall be called the "second deck"; "third deck"; "fourth deck," etc.

7. A partial deck above the lowest complete deck and below the main deck shall be called the "half deck."

8. A partial deck below the lowest complete deck shall be called the "platform deck." Where there are two or more partial decks below the lowest complete deck, the one immediately below the lowest complete deck shall be called the "first platform;" the next shall be called the "second platform," and so on.

9. Decks which for protective purposes are fitted with plating of extra strength and thickness shall be further defined, for technical purposes, as "protective" and "splinter," in addition to their regular names. Where there is only one such deck it shall be defined as "protective" and where there are two, that having the thicker plating shall be defined as "protective" and that having the thinner plating shall be defined as "splinter" in addition to the regular names.

10. Where a protective deck is stepped a complete deck height, the respective portions shall be distinguished by means of the terms "middle protective section" and "forward (or after) protective section" in addition to the regular names. Where a

[1] The Bureau interprets this as meaning that a deck structure, although extending to the line of the ship's side is not an upper deck unless the side plating proper of the ship is carried up and connected to it.

splinter deck is stepped a complete deck height, the respective portions shall be similarly distinguished.

11. Where a portion of the protective or splinter deck is sloped, the sloping portion shall be defined as the "inclined protective deck" or "inclined splinter deck."

§ VIII. THE PRESERVATION OF SHIPS.

Rust. In order to properly preserve the steel structure of a ship from corrosion, or wasting away, means must be provided for preventing the formation of *rust*. The rusting of steel or iron, is the combination of oxygen and iron, this combination being caused by the presence of carbon dioxide in the moist air or water to which the metal is exposed. The carbon dioxide acts upon the iron to form a carbonate, which, in turn, unites with oxygen to form iron rust and new carbon dioxide, and this latter feature accounts for the continuation of the process of rusting, as the new carbon dioxide attacks new iron, causing the process to go on and on until no more iron remains.

The formation of rust is accelerated by heat, as is commonly evidenced by the fact that the portions of the ship's hull near the boilers rust much more rapidly than others; in fact, if the heat is sufficiently great, the iron will oxidize without the presence of moisture. A hot, steamy atmosphere, therefore, is especially conducive of rusting; and consequently, portions of the ship which are exposed to such an atmosphere require special care and attention.

The best preventive of the formation of rust is to provide a coating, such as paint, bitumastic, cement, etc., which shall be impervious to moisture. Details of these preventives will be given later.

Galvanic Action. The corrosion of a ship's structure is also caused by *galvanic action*, an electrical phenomenon which takes place when two dissimilar metals are placed in an acid in metallic contact with each other. An electric current is then set up between the two metals which flows from the *electro-positive* metal to the *electro-negative* metal, and which results in the corrosion of the former. Salt water has the effect of a weak acid upon two dissimilar metals; consequently galvanic action will occur between the different metals comprising the ship's

structure wherever they are in contact with sea water, bilge water, etc., and will cause corrosion of the electro-positive metal. Galvanic action between copper, bronze, lead, and steel results in the corrosion of the steel; that is, the steel is electro-positive to the others; but galvanic action between zinc and steel results in the corrosion of the zinc, this being electro-positive to steel.

Mill scale, formed by the application of water to hot steel while it is being rolled at the mill, is an oxide of iron; and as steel is electro-positive to this scale, it will be seriously corroded if the scale is not removed. This removal can be effected by *pickling* the steel in a weak acid solution, so that the scale becomes loosened and can then be brushed off. Another method is to leave the steel exposed to the weather for some time and allow ordinary rusting to loosen the scale a sufficient amount so that it can be removed by wire brushes.

Steel is also electro-positive to ordinary *rust scale,* so that the presence of rust upon steel tends to increase the corrosion of the steel when it is immersed in salt water. It is very evident, therefore, that all possible means should be taken to remove mill scale and rust scale before the steel hull is painted; otherwise the presence of moisture in the scale will cause galvanic action, with the consequent pitting of the steel and blistering of the paint, resulting in the formation of *rust cones.* If the steel plating is thoroughly dry before painting is done, the chances of corrosion are, of course, greatly lessened.

Not only do different metals cause galvanic action, but it is also true that different grades of the same metal may be subjected to corrosion from galvanic action. In general, the softer, or low-carbon material, suffers the most from corrosion due to this cause. Experience has also shown that steel ships suffer much more from corrosion than iron ships do.

The corrosion of the steel hull by galvanic action may be reduced by the use of *zinc protectors.* These consist of unpainted slabs of rolled zinc, and they are fitted to stern-posts, rudders, strut hubs, etc., when bronze propellers, or other bronze fittings are used, so that the galvanic action which is set up between the bronze and the zinc will corrode the zinc, this being more electro-positive to bronze than is the steel of the hull. As soon as the zinc protectors are badly eaten away, they must be renewed.

Mild steel protecting rings for sea valves have been substituted recently for zinc rings, the steel rings being slightly more electropositive to the composition sea valve than is the steel hull, and they do not require such frequent renewal. There is a tendency at present to do away with all zinc protectors; but pending further experience in service, this has not yet been completely adopted.

Anticorrosive Coatings. There are several distinct varieties of coatings for preventing corrosion; viz., paint, varnish, oil, bituminous compositions, cement, galvanizing, etc., and they are used for different parts of the ship's structure depending upon the various conditions.

Painting is by far the most commonly used method of preventing corrosion; and if all parts of the ship could be kept well coated with paint, there would be practically no danger of corrosion. It is only when paint loses its protective qualities through age or wear, that the metal becomes subject to corrosion. *Paint, or other coatings, should never be applied to damp, oily, or greasy surfaces, or to surfaces which have not been thoroughly scaled and cleaned, and each coat of paint should be allowed to dry hard before the next coat is applied.*

Red Lead has a more extensive use than any other paint. It is used as a priming coat on the entire outer surface of the hull and all metal surfaces exposed to the weather; on all inside work (except metal to which special paint, cement, or oil, or bituminous compositions are to be applied); and on plating behind armor. Red lead has been found by experience to have practically no injurious effect uopn steel, and it has excellent adhesive, wearing and covering qualities.

Ships' Bottom Paints. In addition to the priming coat of red lead applied to the bottom of a steel ship, special paints are also used to prevent corrosion and fouling. A great number of these special paints have been tried from time to time; but in the United States Navy the only bottom paints now used are the standard *anticorrosive* and *antifouling* paints manufactured at the navy yards. The purpose of the anticorrosive paint is to prevent corrosion by separating the metals contained in the antifouling paint from the steel itself. The purpose of the antifouling paint is to prevent fouling of the ship's bottom, oxide of mercury, a poison, being used as an ingredient to

destroy any marine growth which may attach itself to the bottom of the ship. Care should be taken when applying this paint that it does not come in contact with the steel plating; otherwise it will cause corrosion.

Anticorrosive and antifouling paints should always be applied just prior to launching or before undocking; and in general, two complete coats of anticorrosive and one complete coat of antifouling paint are applied. When a ship is docked it is not customary to touch up or paint the bottom with red lead, but the anticorrosive paint is applied directly over the red lead firmly adhering to the steel, or else to the bare metal. Antifouling paint should always be applied just before a ship is put into the water, for the reason that if it is allowed to stand exposed to the air for a period of twenty-four hours or more, it begins to lose its antifouling properties.

Wooden hulls, such as those of submarine chasers, tugs, lighters, etc., are given two coats of an approved *copper paint* in order to prevent fouling, and larger wooden ships and ships having wooden outside planking are *sheathed* with sheet copper for the same purpose. Marine growths do not attach themselves readily to copper as it constantly gives off poisonous salts which tend to destroy them.

Boot-Topping Paint. The region of the hull between the light and the full-load water-lines is particularly difficult to protect against corrosion for the reason that the anticorrosive and antifouling paints deteriorate more rapidly when exposed to air than when immersed in water, and moreover, the plating in this region is subjected to much more chafing than are other portions of the hull. Here a special, quick-drying paint, called *boot-topping,* is used, the principal ingredients of which are varnish and drier. For large ships, the band of boot-topping is four or five feet wide, and for small ships two feet wide.

Bituminous Compositions. It has been shown by experience that the most efficient coating for steel work in double bottoms, machinery spaces, fresh water tanks, and similar spaces is a material composed of coal tar, pitch, or asphalt. Bituminous composition, or "bitumastic," consists of *bituminous solution,* which is applied cold with a brush as a priming coat; and *bituminous enamel,* or *bituminous cement,* which are applied hot, over the solution. The cement is suitable for flat, horizontal

surfaces, and is spread on to a thickness of at least one quarter of an inch, while the enamel is suitable for overhead, vertical, or inclined surfaces, and is applied to a thickness of at least one sixteenth of an inch.

Bituminous compositions should be applied only to surfaces which are *thoroughly dry and clean,* and *free from paint, oil, grease, or rust;* and if practicable, they should be put on when the ship is out of water. Artificial ventilation should always be furnished when bituminous compositions are being applied in confined spaces as their fumes are liable to overcome the workmen in their vicinity.

Portland Cement. In many ships the inner surface of the shell plating is coated with *cement* to prevent corrosion, and also to prevent the wearing away of rivet heads and plating through the constant washing to and fro of the bilge water and the foreign substances sometimes contained therein. No Portland cement is used in the double bottoms of United States ships; but *cement wash,* consisting of cement and fire clay, is applied with a brush to the inside of reserve feed water tanks, care being taken that the metal is thoroughly dry when the wash is applied.

Galvanizing is another method of preventing corrosion, and consists in thoroughly cleaning the metal in an acid bath, and then applying a coating of zinc, either molten (the hot process), or by electrolytic methods. It is used chiefly for protecting deck fittings, such as rails, stanchions, bitts, chocks, cleats, bolts, etc. It is also used, in addition to paint, for protecting the steel structure of destroyers, for the reason that the hulls of these vessels are built of such light material that only a small margin is allowed against corrosion.

Special Measures to Prevent Corrosion, U. S. Navy. Whenever a ship of the United States Navy is docked at a navy yard, the condition of the ship's bottom is examined by a specially appointed "Paint Board," and a complete report concerning this condition is forwarded to the Bureau of Construction and Repair.

In addition to this board, a "Hull Board" is always appointed by the commanding officer of every ship, and it is the duty of this board to examine and report upon the condition of every part of the ship as regards corrosion or deterioration, and to

make such comment and recommendation as are pertinent to the subject.

§ IX. DIRECTIONS FOR MAKING TURNING TRIALS AND OBTAINING TACTICAL MANEUVERING DATA FOR VESSELS OF THE UNITED STATES NAVY. (Plate 194.)

Turning trials shall be made under conditions that permit accurate results to be obtained, and if there be any doubt as to the accuracy of all the data required, the trials shall be repeated at favorable times until the required accuracy is assured.

When this data is once accurately obtained for a ship there is no necessity for a repetition of the trials, unless changes have been made in the hull or machinery that may affect the turning qualities.

The special reports made on the subject will be reviewed by officers of the Navy Department, who will scan them carefully and systematically tabulate the results. Due credit will be given to succeeding commanding officers who may be able to furnish additional information whenever an opportunity occurs.

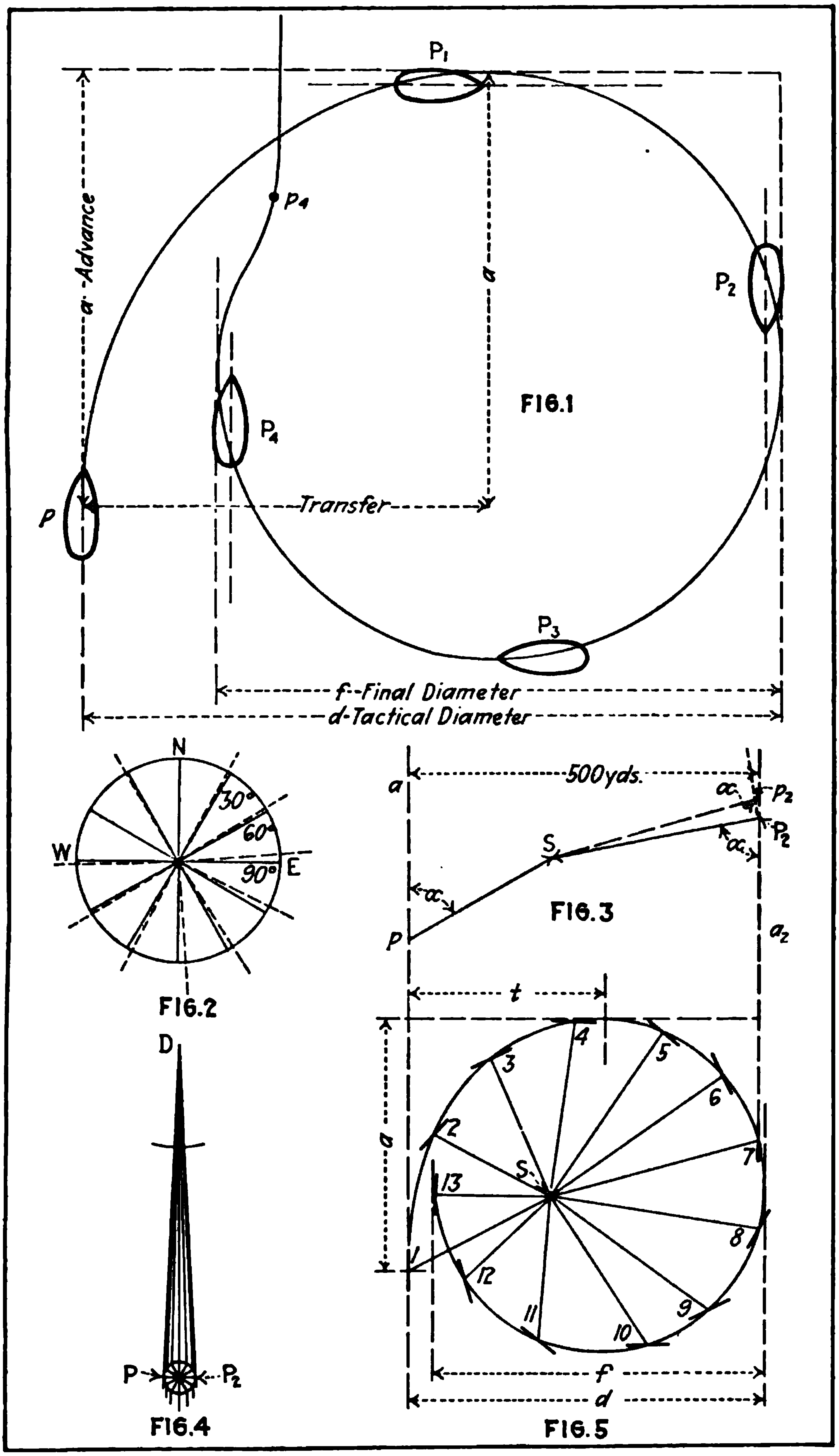
In order that there may be uniformity in the terms used, a thorough understanding of the information required, and of the manner in which the data may be obtained, the following method is given.

Let P, P_1, P_2, P_3, and P_4 represent the successive positions of a ship in making a complete turn with right rudder from the instant of beginning to put the rudder over at P, to the instants when a change in heading of 90° at P_1, 180° at P_2, 270° at P_3, and 360° at P_4 is made.

The most desirable data is that which fixes the positions P_1 and P_2 with reference to P and gives us a, the "advance," t, the "transfer," and d, the "tactical diameter."

It is thought that each vessel's "final diameter," f, will be practically constant at all speeds for the same conditions of draft and rudder angle, the differences in the tactical diameters for different speeds being due principally to the differences in time required to put the rudder over and the different distances run (at the different speeds) before the rudder is over.

It is very important to know how to modify the rudder angles in order to turn upon practically the same curves as some other designated ship, or upon standard curves adopted by the commander in chief.



PLOTTING TACTICAL DATA.

It is particularly desirable to know the "advance," "transfer," and "tactical diameter" with screws on one side backing.

It is also advantageous to know the following:

The distance the ship will travel and the rate at which she loses speed, when all engines are suddenly reversed, before she can be brought to a dead stop.

The rate at which the ship loses speed after all engines are stopped or disabled.

The rudder angle required to keep the ship on a steady course when screws on one side are stopped or disabled, and the actual speed made under such conditions.

The "advance," "transfer," and "tactical diameter" with full rudder and starting from a dead stop.

It is very desirable to know the rate at which the ship regains her initial speed after a turn has been made.

Theoretically, the tactical data of twin-screw and four-screw ships for turning to right ought to be the same as that for turning to left, the speeds and rudder angles being the same, but practically slight differences in results may be expected, owing to differences in the working of the engines and other outside influences during the times of trial. The mean of the right and left determinations, one following the other closely, made under identical conditions, will therefore be regarded as the standard. The data for complete turns, with both right and left rudder, will be required for speeds and for rudder angles as follows (the mean of the right and left determinations shall be used at the different speeds and rudder angles):

All engines ahead—full rudder (35°, or whatever it is).

All engines ahead—rudder angle, 20° to 25°.

All engines ahead—rudder angle, 10° to 15°.

Engines on one side full speed astern—full rudder.

From a dead stop, turn with power corresponding to speed at which the other ahead trials are being made.

The above trials shall be made for each of the following speeds:

For vessels having designed speed of—	Speed A.	Speed B.	Speed C.	Speed D.
Over 30 knots	Full speed	20	15	10
Between 20 and 30 knots	do.	15	....	10
Between 15 and 20 knots	do.	12	....	10
Less than 15 knots	do.	10	....	8

Find the time and distance in which the ship can be brought to a dead stop, rudder amidship, and the rate at which she loses speed, by backing full speed, both from "full speed" ahead and from a speed of 10 knots.

Find the time in which a vessel loses speed down to 5 knots after the engines are stopped, both from "full speed" ahead and from a speed of 10 knots; and thence deduce the rate of losing speed per knot.

Find the rudder angle necessary to keep the ship on a steady course, under full power, with engines on one side stopped or disabled, and the actual speed made under such circumstances.

Find the rate of increase in the speed on straightening out the course after making each of the above complete turns.

It should always be borne in mind that due credit will be given for additional information, as, for instance, obtaining the data of opposite turns and other speeds or rudder angles than those required, or noting special peculiarities of behavior under the varying influences of wind and sea.

The conditions under which the turning trial should take place are as follows: (1) The depth of water should be sufficient to prevent the drag on the bottom from influencing the speed. (2) The tidal movement in the locality should be small, unobstructed, and uniform. (3) There should be a clearly defined distant object in view. (4) The weather and sea should be smooth, a dead calm being preferable.

The following methods have been tested and will give accurate results if carefully and patiently followed. The essential features are:

(*a*) Observations of the change of heading, from a dumb compass on board, with reference to a fixed external object.

(*b*) Bearings of an observing boat or ship from an azimuth instrument on board, with reference to the keel line of the ship, the boat not being anchored but moored to a drag sunk to a depth corresponding to the draft of the ship. A pole weighted to float at the proper depth with a flag at its staff may be used, the observers then to be in a boat under oars whose bow shall be kept close to the pole as it floats. If an observing sister ship is used, both ships take reciprocal angles and bearings, and the observing ship records the speed and direction of her drift during each turn.

(*c*) Ranges or distances of the ship taken from the observing boat or ships.

These observations to be simultaneous.

TAKING THE OBSERVATIONS.

The observer A should be the officer directing the movements of the ship, and a convenient dumb compass may be quickly arranged by ruling, with pencil lines, a dumb card on tracing cloth, showing only the lines of bearing for every two points, or, if the view from the standard compass is fairly clear all around, for every 30°. Paste this on the glass face of the standard compass with three or four spots of photographic paste (after the trials it may readily be removed) having the *N* point of the card coincide with the lubber's point of the compass. If desired, the circuits to the gyro compass repeater may be cut out and the repeaters (with azimuth circles) used as dumb compasses or peloruses.

Have a hand stationed at the whistle pull instructed to give the whistle a quick, sharp blast whenever observer A says "Mark." Have, near observer A, a recorder with a watch ready to record the time of each order "Mark" and the observations of observer B, placing them opposite the reading of the dumb compass for that mark.

The accuracy of results will be increased if observer A is provided with an electric contact maker in circuit with the automatic whistle. When he gives the order "Mark" he can simultaneously make the contact which will cause the whistle to blow, thus avoiding loss of time and irregularity due to having this duty performed by another man. It will be a simple matter for the electrical force to insert a contact maker in the circuit of the solenoid which operates the whistle in place of the automatic circuit closer.

Observer B, stationed abreast of the foremast, or at the most convenient point for observations, is to note at each order "Mark" the angle between the keel line of the ship and observer C (in the boat) from forward aft. For this purpose a pelorus may be used if care be observed to note accurately the angle, with the instrument level. If a pelorus on each side is to be used, there should be two contact makers in parallel, one at each pelorus, and

so located as to enable the observer to operate them with ease while observing the object. If there is any difficulty about the observers in the engine rooms hearing the whistle signals, electric bells or lamps should be installed there on temporary circuits which are also controlled by the contact makers at the peloruses. The circuits for these bells or lamps should be in parallel with the solenoid circuit and the contact maker should be in the feeder or branch circuit from the dynamo which supplies them with current.

Observer C has, in the boat with him, a man instructed to watch the steam whistle and to say "Mark" the instant a puff of steam is seen to issue from the whistle, also a recorder with a timepiece to record the time and ranges. Observer C keeps the reflected image of the fore truck at the water line by his instrument and at each order "Mark" calls out the range or angle for his recorder to note. The stadimeter is handy for this purpose, but the ship may get too near for accurate observations and the stadimeter may get out of adjustment. Sextant angles, if read to seconds, give greater safeguard of accuracy, although they require more time and trouble in preparing the data for plotting.

An observer, D, in the engine room, assisted if necessary, should record the angle of heel and the actual reading of each revolution counter at each blast, also the revolutions per minute of each engine, before each turn.

After a turn is begun, no change in position of the throttle valves will be made until the turn is completed.

All recorders should be prepared, before the trials, with pads and blanks suitably ruled to record the observations.

The distant object.—A tactical diameter of 500 yards will subtend about 1° of arc if the distant object be 15 miles away, 1½° if 10 miles, and 3° if 5 miles. It is generally difficult to get a well-defined object sufficiently distant to neglect the parallax in plotting, and it is preferable to have the object sufficiently near and distinct to obtain its distance on the chart and to take account of its distance in the plotting. Therefore, at the end of each turn take sufficient bearings (or 3-point angles) to plot the position of the ship and thus determine the distance of the object used. If observer C uses a sextant, he will be the best equipped to take this observation, the angles between

three suitable objects on shore. If observer C uses a stadimeter, he should have also a sextant at hand ready to use.

TO EXECUTE THE MANEUVER.

After dropping the boat, stand off far enough to be able to gain the desired speed before beginning the turn. Hoist a preparatory signal. Shape a course to head for the distant object and at the same time to pass the boat at a safe distance and have it inside the turning circle. It would be practicable to get the observations by turning so as to leave the boat outside of the turning circle, but turning around the boat is entirely practicable and not only conduces to greater accuracy in the observations of C, but facilitates the observations of B, who thereby gets unobstructed views of C from one side of the ship only during the same turn.

As the dumb compass takes no account of magnetic bearings, the initial course will read "North" on the dumb card. When observer C bears 3 points forward of the beam, "mark" and put the rudder over as quickly as possible, with the same force that is used every day or in action, the recorder noting the time required to put it over, the direction it is put over (right or left), and the number of degrees of rudder. Now shift the azimuth circle to cover the next line of the dumb compass, NNE. or 30°, as the case may be, if turning to port, and as the distant object is just coming onto the vertical line "mark" again. Repeat this for each line of the dumb card until the full turn has been made, then shift the rudder, straighten out on the original course, and stand on toward the distant object for at least one minute, "marking" again at intervals of 15 seconds. Haul down the "preparatory signal." Note the direction and force of wind. Observer C takes observations for plotting the position of the boat. Prepare for another turn.

If the same distant object be used for all the turns, the ship will now require to make two half turns before being in position for another exact maneuver, but if a second distant object be available in a nearly opposite direction, the ship may stand on after the first full turn, and, after running the required distance, return to another trial after making one half turn only.

In all these turns put the rudder over as quickly as possible,

even when 10° only is required. Uniformity in this matter is important.

During the turns it may be that a mast or a smokestack will interfere with a direct view from the compass of the distant object while at some one of the bearings on the card. When this occurs, estimate as near as possible when the object would be on that bearing and give the order "Mark" as usual. Tell the recorder to put a question mark (?) after that observation. This will preserve the number and order of the observations and assist in the plotting.

To obtain the distance the ship will run and the rate of decrease in speed, after reversing the engines, or after stopping the engines, stand on a straight course past the observing boat, "mark" when the engines are reversed or stopped, "mark" again at intervals of fifteen seconds and again when the ship has stopped dead in the water.[1]

The angles observed by B and the distances by C will enable the maneuver to be plotted and the distances measured. From this data curves may be constructed to show the rate at which the speed is decreased.

This method may be employed by two ships working in concert, one as the observing boat; but to get the data for both ships it requires twice as much time as if each ship worked singly, and good judgment forbids that the turns be made around the observing ship. The importance of doing the work during a smooth period favors the use of a boat. When another ship is used as the observing boat, however, great care must be used to see that she has no headway during the turns.

TO PLOT THE WORK. (Plate 194.)

Upon a drawing board, construct a dumb compass card, fig. 2, similar to that used by observer A, for plotting the right turns and upon another sheet a similar dumb compass card for the left turns; a condemned chart with its compass rose may prove convenient. Select a fixed point, *S*, fig. 3, to represent the posi-

[1] It is not necessary to keep on observing until the ship has stopped during the maneuver of stopping the engines only. This would require a useless waste of time.

tion of the observing boat. Place the protractor on the dumb compass course north and mark the angle, a, of B's first observation (say 60°). Carry that line down to S and lay off the distance SP, C's first observation.

Now do the same construction for the position P_2, at the 180° turn, and measure the shortest distance between Pa and P_2a_2. This will be approximately the tactical diameter (say 500 yards). Lay off this distance PP_2, fig. 4, on the chart scale at right angles to PD, the distance of the "distant object." Draw a miniature and similar dumb compass at PP_2. The lines connecting each of the successive points with D will represent the *true* bearing of D, from 0° and 360° at P to 180° at P_2. PD, fig. 4, is the true bearing of Pa, fig. 3, and P_2D, fig. 4, of P_2a_2, fig. 2, so that the position p_2 instead of P_2, fig. 3, becomes the true position at 180°, or the seventh point of observation.

Now correct the dumb compass, fig. 3, for the parallax of each point of observation according to fig. 4, as shown by the dotted lines in fig. 2, and continue the plotting of the various points of observation in fig. 3 with the corrected bearings shown by dotted lines in fig. 2.

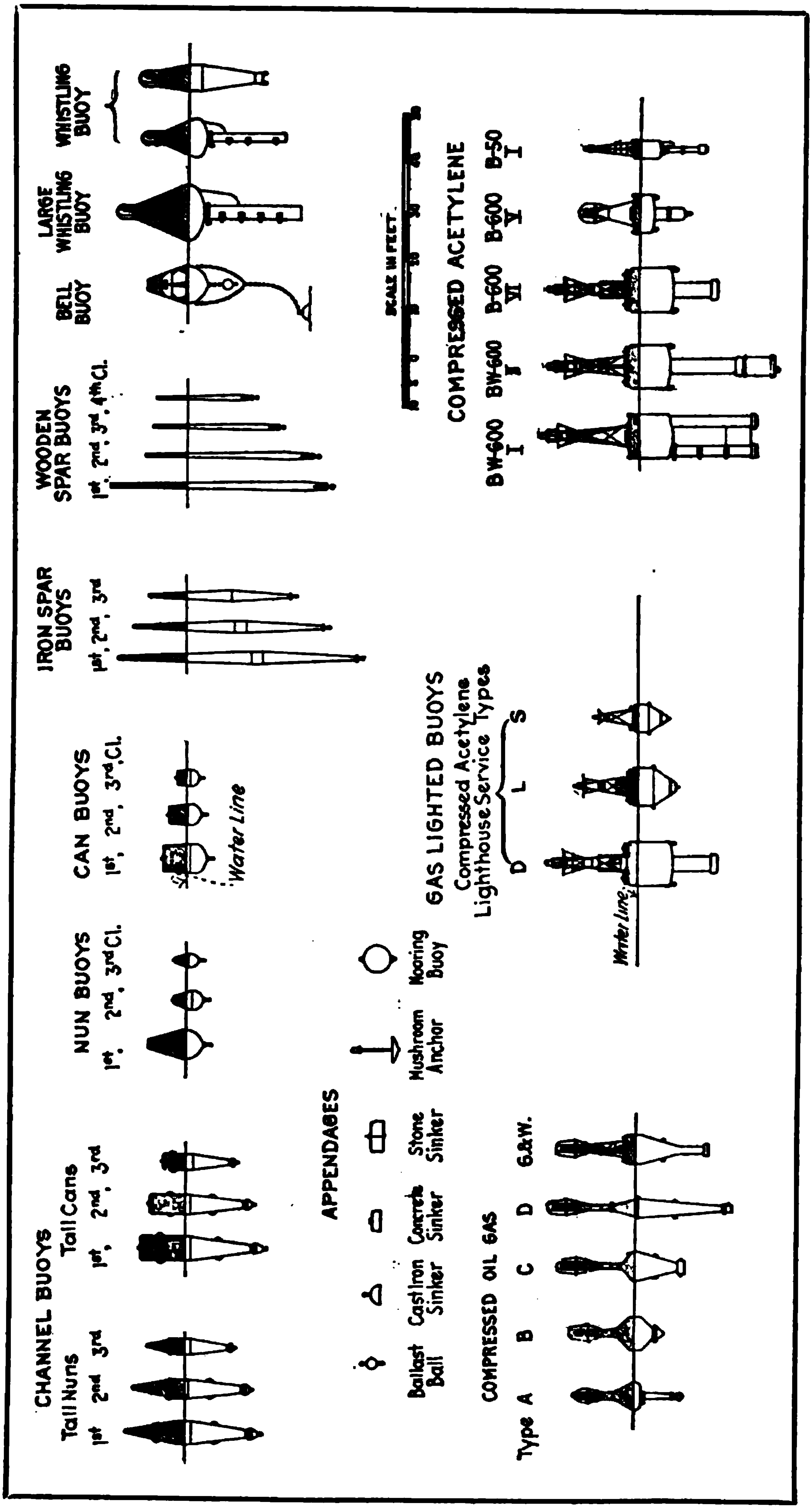
Connect the various points by a fair curve, fig. 5, correcting inconsistencies and doubtful observations, and construct tangents from which the data a, t, d, and f may be measured. The "drift angle" will be the angle between the keel line and the tangent to this curve at any point of observation.

The result of these observations shall be entered upon the form hereto attached.

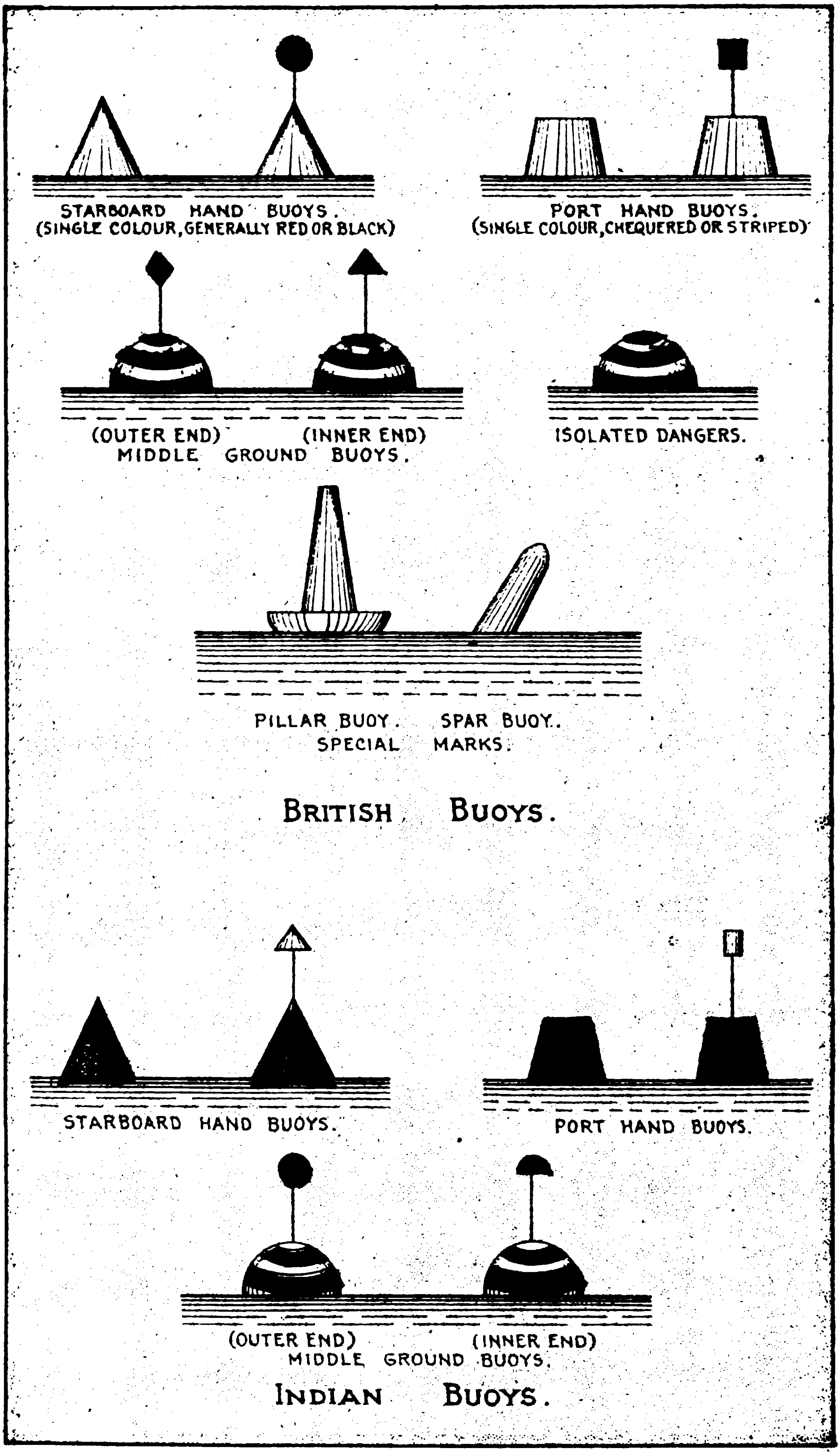
NOTE.—*The pamphlet dealing with this subject issued by the Navy Department (from which the foregoing is taken) contains also instructions for determining tactical data using the sun as a distant object.*

§ X. BUOYAGE.

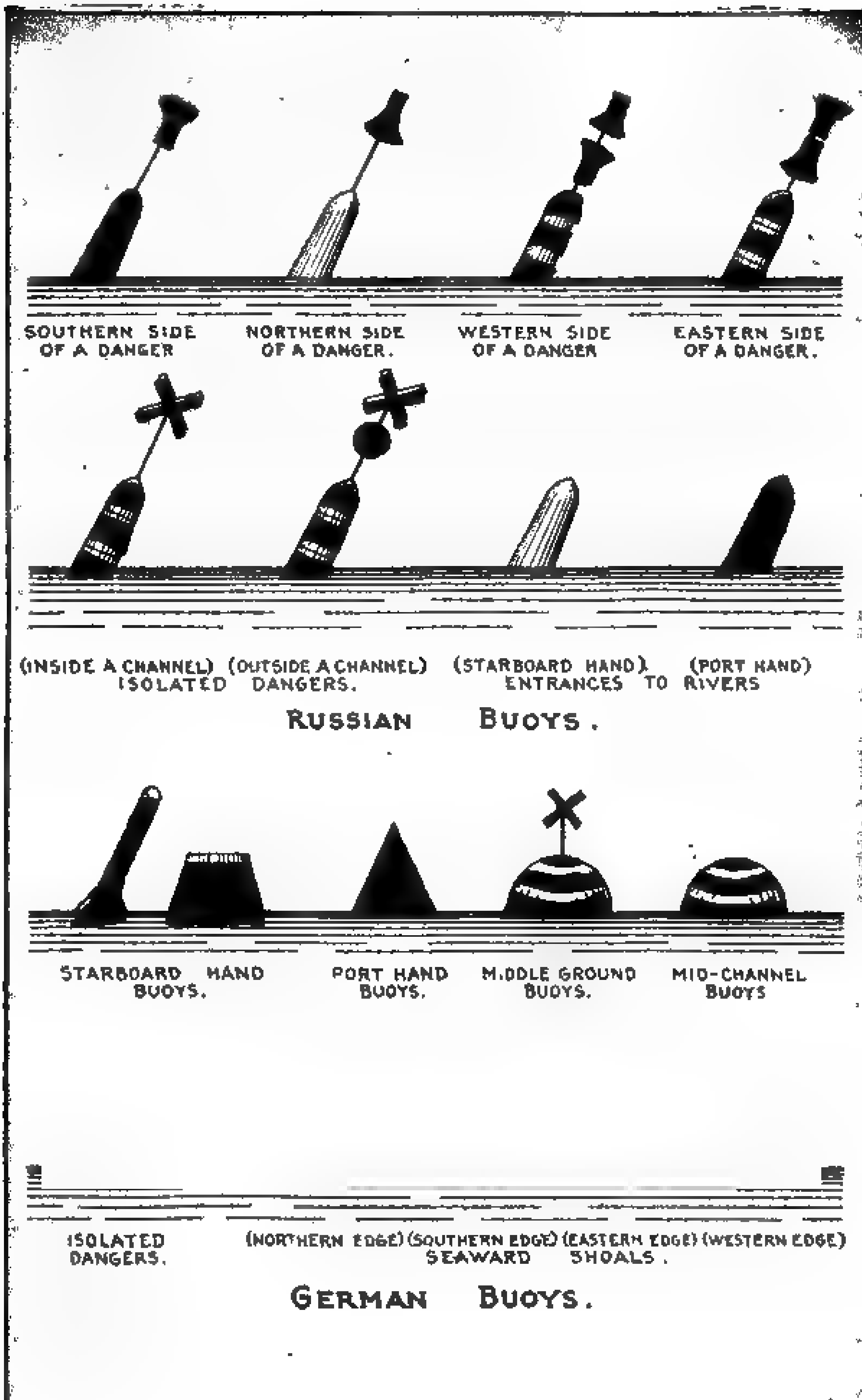
Plates **195**, **196**, **197** and **198** show the systems of buoyage at present used by the principal maritime powers. These plates are put here rather than in Chapter XVI because they are subject to change.



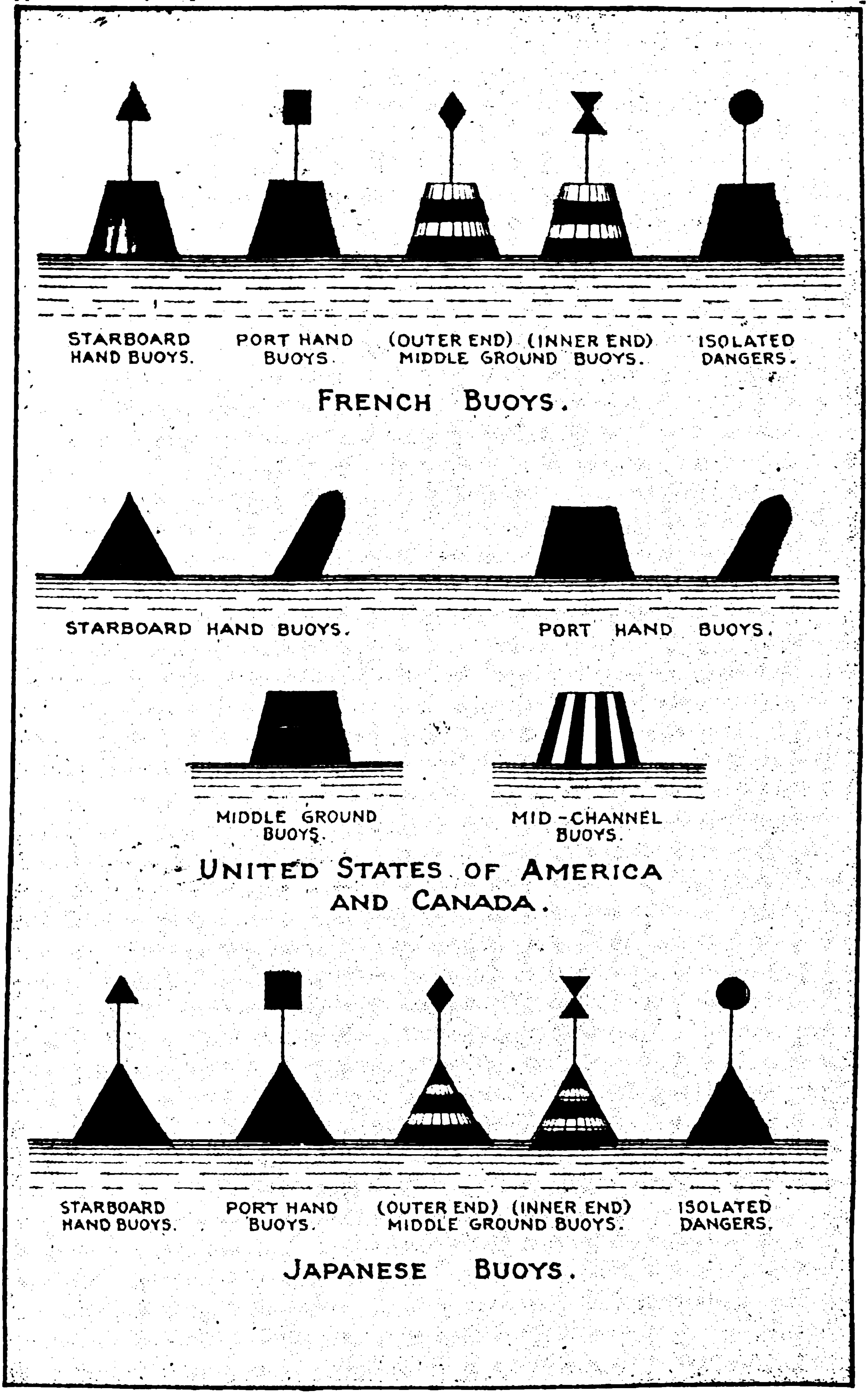
TYPES OF BUOYS IN UNITED STATES WATERS.


STARBOARD HAND BUOYS.
(SINGLE COLOUR, GENERALLY RED OR BLACK)
PORT HAND BUOYS.
(SINGLE COLOUR, CHEQUERED OR STRIPED)
(OUTER END) (INNER END)
MIDDLE GROUND BUOYS.
ISOLATED DANGERS.
PILLAR BUOY. SPAR BUOY.
SPECIAL MARKS.
BRITISH BUOYS.
STARBOARD HAND BUOYS.
PORT HAND BUOYS.
(OUTER END) (INNER END)
MIDDLE GROUND BUOYS.
INDIAN BUOYS.

BUOYAGE.


SOUTHERN SIDE OF A DANGER
NORTHERN SIDE OF A DANGER.
WESTERN SIDE OF A DANGER
EASTERN SIDE OF A DANGER.
(INSIDE A CHANNEL) (OUTSIDE A CHANNEL) ISOLATED DANGERS.
(STARBOARD HAND) (PORT HAND) ENTRANCES TO RIVERS
RUSSIAN BUOYS.
STARBOARD HAND BUOYS.
PORT HAND BUOYS.
MIDDLE GROUND BUOYS.
MID-CHANNEL BUOYS
ISOLATED DANGERS.
(NORTHERN EDGE) (SOUTHERN EDGE) (EASTERN EDGE) (WESTERN EDGE) SEAWARD SHOALS.
GERMAN BUOYS.

BUOYAGE.


STARBOARD HAND BUOYS.
PORT HAND BUOYS.
(OUTER END) (INNER END) MIDDLE GROUND BUOYS.
ISOLATED DANGERS.
FRENCH BUOYS.
STARBOARD HAND BUOYS.
PORT HAND BUOYS.
MIDDLE GROUND BUOYS.
MID-CHANNEL BUOYS.
UNITED STATES OF AMERICA AND CANADA.
STARBOARD HAND BUOYS.
PORT HAND BUOYS.
(OUTER END) (INNER END) MIDDLE GROUND BUOYS.
ISOLATED DANGERS.
JAPANESE BUOYS.

BUOYAGE.

§ XI. DIRECTIONS FOR RESTORING THE APPARENTLY DROWNED.

THE SCHAFER METHOD. Plate 199.

1. Generally speaking, the same steps are followed in the Schafer Method as in any other method; namely, remove the water from the lungs, clear the air passages, restore breathing, remove wet clothing, and stimulate by heat and friction. The difference between the Schafer Method and the Sylvester Method, which has heretofore been generally recommended and practiced, is in the manner of restoring respiration.

The simplest method whereby water may be removed from the lungs, and incidentally from the stomach, which often contains considerable water which has been swallowed, is by placing the patient face down, clasping your hands under his abdomen and raising him sufficiently to permit the water to run from the air passages, lungs and stomach.

SCHAFER METHOD OF RESTORING RESPIRATION.

2. After removing water from the lungs and clearing the air passages, place the patient on his abdomen with his face protected by clothing and turned to one side so that the mouth and nose are free for breathing. Kneel beside him, or, if preferred, astride him, with your knees at his hips, and facing towards his head; place the palms of your hands on the small of his back, the base of the palms in line with the spinal column, thumbs extended and nearly touching and fingers slightly extended. First movement: Lean forward and gradually bring the weight of your body on your hands, the movement taking two or three seconds. Avoid all approach to roughness, such as might injure the internal organs. The object of the movement is to compress the lower part of the chest and abdomen, forcing the air and water out of the lungs. Second movement: Swing backward, releasing the pressure quickly but leaving your hands in place. The object of this movement is to allow the lungs to expand with the release of pressure and therefore for air to rush in to fill up the air spaces of the lungs. These two movements of compression and release simulate natural breathing and the move-

TO REMOVE WATER FROM LUNGS

REVIVING THE APPARENTLY DROWNED.

ments should be so regulated as to be completed about fifteen times to the minute, each double movement occupying about four seconds. Continue the artificial respiration until the patient breathes, and for a while after signs of returning life, carefully aiding the first short gasps until deepened into full breaths.

AFTER TREATMENT.

3. *Externally:* As soon as breathing is established let the patient be stripped of all wet clothing, wrapped in blankets only, put to bed comfortably warm, but with a free circulation of fresh air, and left to perfect rest. The warmth of the body may be promoted by brisk rubbing of the limbs, the rubbing being always *toward* the body, by the application of hot flannels to the stomach and armpits, and bottles of hot water, heated bricks, etc., to the limbs and soles of the feet.

Internally: Give whisky or brandy and hot water in doses of a teaspoonful to a tablespoonful every ten or fifteen minutes for the first hour, and as often thereafter as may seem expedient. If neither whisky nor brandy is at hand, some other stimulant may be substituted.

LATER APPLICATIONS.

4. After reaction is fully established there is great danger of congestion of the lungs, and if perfect rest is not maintained for at least forty-eight hours it sometimes occurs that the patient is seized with great difficulty of breathing, and death is liable to follow unless immediate relief is afforded. In such cases apply a large mustard plaster over the breast. If the patient gasps for breath before the mustard takes effect, assist the breathing by carefully repeating the artificial respiration.

§ XII. INSTRUCTIONS FOR SAVING DROWNING PERSONS BY SWIMMING TO THEIR RELIEF.

1. When you approach a person drowning in the water assure him with a loud and firm voice that he is safe.

2. Before jumping in to save him, divest yourself as far and as quickly as possible of all clothes; tear them off if necessary; but if there is not time, loose at all events the foot of your drawers,

if they are tied, as, if you do not do so, they will fill with water and drag you.

3. On swimming to a person in the sea, if he be struggling do not seize him then, but keep off for a few secouds till he gets quiet, for it is sheer madness to take hold of a man when he is struggling in the water, and if you do you run a great risk.

4. Then get close to him and take fast hold of the hair of his head, turn him as quickly as possible onto his back, give him a sudden pull, and this will cause him to float, then throw yourself on your back also and swim for the shore, both hands having hold of his hair, you on your back and he also on his, and of course his back to your stomach. In this way you will get sooner and safer ashore than by any other means, and you can easily thus swim with two or three persons; a good swimmer has, as an experiment, done it with four, and gone with them 40 or 50 yards in the sea. One great advantage of this method is that it enables you to keep your head up and also to hold the person's head up you are trying to save. It is of primary importance that you take fast hold of the hair and throw both the person and yourself on your backs. After many experiments, it is usually found preferable to all other methods. You can in this manner float nearly as long as you please, or until a boat or other help can be obtained.

5. It is believed there is no such thing as a *death grasp;* at least it is very unusual to witness it. As soon as a drowning man begins to get feeble and to lose his recollection, he gradually slackens his hold until he quits it altogether. No apprehension need, therefore, be felt on that head when attempting to rescue a drowning person.

6. After a person has sunk to the bottom, if the water be smooth, the exact position where the body lies may be known by the air bubbles, which will occasionally rise to the surface, allowance being of course made for the motion of the water, if in a tideway or stream, which will have carried the bubbles out of a perpendicular course in rising to the surface. Oftentimes a body may be regained from the bottom, before too late for recovery, by diving for it in the direction indicated hy these bubbles.

7. On rescuing a person by diving to the bottom, the hair of the head should be seized by one hand only, and the other used in conjunction with the feet in raising yourself and the drowning person to the surface.

8. If in the sea, it may sometimes be a great error to try to get to land. If there be a strong "outsetting" tide, and you are swimming either by yourself or having hold of a person who can not swim, then get on your back and float till help comes. Many a man exhausts himself by stemming the billows for the shore on a back-going tide, and sinks in the effort, when, if he had floated, a boat or other aid might have been obtained.

9. These instructions apply alike to all circumstances, whether as regards the roughest sea or smooth water.

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